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A computerized morphological database of safety and health issues in bathroom design

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TABLE OF CONTENTS

TABLE OF FIGURES

ABSTRACT

Safety and health issues have been the concern of environmental designers for more than a decade now. This concern arises from the understanding the fact that accidents and unhealthiness result from normal behavior in unsafe environments and thus can be eliminated to a great extent through a careful design process. Moreover, designers have come to realize that designing safe and healthful environments is their legal responsibility.

Statistically, the bathroom is the most dangerous space in and around the home. Moreover, a number of factors make the bathroom one of the least healthful places in the home. For these reasons, bathrooms should be targeted for particular health and safety attention by environmental designers. Hence, the intention of this study is to provide designers both with information focused on a wide range of safety and health problems related to the bathroom and with potential solutions.

By using a morphological approach and computer applications, this study has attempted to provide such information in a quickly retrievable and easily understandable form. Because environmental design is a complex combination of two-dimensional and three-dimensional components, each design component in the bathroom was analyzed individually.

CHAPTER I. INTRODUCTION

Background

Bathrooms

Not long ago, the bathroom was the most neglected space in the home, but today it receives as much attention as any other living area. The bathroom is the only space in which we can enjoy almost perfect privacy, a totally relaxed feeling, and the most intimate physical contact. It is the one facility in the home that everyone uses every day and no one would be unwilling to do without. Kira (1976) states that the bathroom is a "positive environment" oriented towards health, exercise, relaxation, and bodily rejuvenation. Nowadays, the bathroom is conceived as a space to be shared by the entire family as a natural part of daily living.

Today's bathrooms have a tendency to combine other residential functions. Smoking, eating, and drinking are fairly common incidental activities while one is grooming and bathing. Reading and listening to the radio or watching television are other common diversionary activities in the bathroom. Furthermore, Americans' current passion for health and fitness now promises to have a major influence on bathroom planning. The conception of the "living bath" is already common in Japan and is gaining popularity in some parts of North America and European markets as well (Kira, 1976). Scandinavian saunas and hot-tubs in California are good examples. Consequently, bathrooms are becoming bigger and more luxurious. Recent research shows that

Americans spend $6.8 billion on new and improved bathrooms every year (Davidsen, 1989). Cornish (1986) has even predicted that in the future it may be common for guests to be entertained in the bathroom. Thus, the traditional preconceptions of the bathroom may no longer be valid. Already it is no longer merely a space for personal hygiene and therefore, it may be assumed that much more time is spent in the bathroom than before.

Health and Safety in the Bathroom

Despite its importance, because certain precautions have not been taken at appropriate stages of planning, the bathroom has historically been one of the most dangerous rooms in a building or home. But, as we spend more time in the bathroom, we should become more concerned about its inherent safety problems. The causes of accidents are not only carelessness, but also normal behavior in unsafe environments (BOSTI, 1978). Clearly, some safety problems caused by the environment are beyond designers' control. Nevertheless, designers are increasingly being held liable for building safety; in short, they are becoming legally liable for injured persons or damaged property arising from unsafe conditions (Coplan, 1981). The January 4, 1981 New York Times reported pending in city courts 469 personal injury and property damage claims from slips and falls. Even though accidental injury lawsuits are usually filed against building owners, building designers can eventually become involved in the litigation. According to a rule established in 1981 in New York, building designers may be liable to third persons for a negligent design, even if the resulting defect is observable and the injury occurs many years after the designer has performed his services (Coplan, 1981). It is imperative, therefore, that designers predict the ultimate effects or results of their proposed design and eliminate unsafe conditions.

Particularly now that we are spending more time in the bathroom, not only safety, but also broader health issues must be emphasized during the planning process. Because the bathroom is generally the most humid place of the house, it has the potential to become the least hygienic place as well. Micro-organisms thrive in its humid environment and poor design can actually aggravate this problem. Consider the example of carpets. In order to make the bathroom more comfortable and luxurious, and also to prevent falls, carpet is often used on floors instead of hard materials such as ceramic tile, stone, and vinyl asbestos tile. Although most carpets have acceptable slip-resistant characteristics when wet, they pose the hazard of biological contamination. How can we enjoy the satisfying feelings of relaxation and privacy worrying about the possibility of accidents and health problems?

Ultimately, health and safety issues are among the most important design factors. Yet while there is a large body of information on health and safety issues, it is rather general and diffuse. It is also difficult for designers to apply this information to their designs without spending a good deal of time in interpretation. Designers are accustomed to visual media rather than descriptive media. The Buffalo Organization for Social and Technical Innovation (BOSTI) (1978) points out that, even though much material and information about safety and accidents have been produced, they have not been very useful to designers, builders, or homedwellers because such materials are fragmented, idiosyncratic and abstruse. What is needed is in some means of organizing this limited body of information so as to give focus to existing concepts and future research needs.

The Present Study

Purposes of the study

The purposes of this study are twofold: first, to provide designers with an expanded base of information on the health and safety implications of the bathroom; second, to explore and demonstrate both the morphological approach and the personal computer as combined tools of design information management.

To provide designers with information on these issues, a careful review of the safety and health literature was conducted. Through this investigation, objectives for the study were developed.

Objectives

The objectives of this study are:

1. develop a list of safety and health considerations in bathroom planning for environmental designers.

2. develop a comprehensive, easy-to-understand morphological format based on commercially available personal computer software.
3. demonstrate the use of this format by showing a representative, adaptable collection of at least 100 individual records.

Steps taken

Several steps were undertaken to accomplish the purposes of this study:

1. investigation of information related to general safety and health issues.
2. review of literature related to design information organization, with emphasis on morphological approaches.
3. selection of information specifically applicable to bathroom design, primarily information dealing with residential applications.
4. establishment of a framework according to which gathered information could be organized.
5. condensation and organization of gathered information into a form easily expressed in a morphological arrangement.
6. development of an illustration describing each information entry.
7. refinement of information entries into a uniform morphological data-base.

Scope of the Study

Even though the topic of this study has been restricted within narrow limits, it has not been feasible to cover this topic exhaustively. Certain types of literature, particularly that pertaining to special groups and the elderly, and dimensional information, are extremely voluminous. In such areas, only a few representative data units are included to illustrate how they fit into the information framework.

Although an effort was made to develop illustrations in a visually cohesive and meaningful style, these illustrations were not intended to represent the highest possible level of technical refinement.

Analysis has been focused on the collection and organization of information drawn from the professional technical literature; at times, opposing views are cited. Interpretation and use of this information rests with the end user. Thus, no effort has been made to explain or eliminate ambiguous or contradictory points of view.

CHAPTER II. LITERATURE REVIEW

Overview

Most available information related to the safety of building users is quite general and broadly applicable, rather than focused on specific environments. In general, the literature can be subdivided into two broad topics: 1) safety factors--those related to accidents and other influences on the immediate physical well-being of the individual; and 2) health factors--influences on the long term well-being of the individual. This is a useful distinction. To be useful to the designer however, the literature needs to be organized into even more discrete subunits. It also needs to be examined in terms of its relevance to the physical feature common to specific settings. Consequently, this chapter reviews the subcategories of safety and health threats, particularly as they relate to the bathroom. This goal is pursued in four steps:

1) The general literature was reviewed, with emphasis on their relation to health and safety in bathrooms.
2) The specific threats contributing to overall health and safety problems are defined.
3) The bathroom is subdivided into its basic subparts.
4) Significant relations between individual threats and components are identified and summarized.

Statistical Background

According to a survey conducted by the National Safety Council in 1988, disabling injuries in the United States, numbered 9.3 million, including 340,000 that resulted in some degree of permanent impairment. Moreover the death total in that year was approximately 96,000--a two-percent increase from 1987 (Hoskin, 1989). Disabling injury totals for the principal classes of accidents were as follows: motor-vehicle,1.8 million; public nonmotor vehicle,2.2 million; home, 3.5 million; work, 1.8 million (duplications of motor-vehicle with other classes numbered 200,000). More than 38 percent of total injuries happened in the home. Furthermore, the death rates for all accidents in 1988 show the seriousness of home accidents. The most important accident types in 1988 were motor-vehicle accidents and falls, 51 percent and 12 percent of the death total respectively. The 1988 death rates per 100,000 population for the principal classes of accidents (and the changes in these rates from 1987) were as follows: public nonmotor vehicle, 7.1 (down one percent); work, 4.4 (down four percent); and home, 9.4 (up seven percent). The motor-vehicle death rate per 100 million vehicle miles was 2.46, also less than in 1987 (Hoskin, 1989). As can be seen from these figures, the home has been the only item showing an increased death rate in 1988. Over 23,000 fatal accidents happened at home in that year alone.

Safety problems in bathrooms were already clearly observable in the statistical data surveyed in 1969 by the Department of Housing and Urban Development (Teledyne Brown Engineering Co., 1972). In that survey, accidents involved solely with tubs and showers accounted for almost 20 percent of total home accidents. Furthermore, only tubs and showers were the only item recording a death rate as high as 1.4 %. Consumer activist Ralph Nader reported in the mid-1970s that nearly 900 Americans died every year as a result of injuries suffered in bathrooms, and that another 187,000 were hurt seriously enough to require hospitalization or emergency room treatment (Miller, 1976). The 1988 data by the National Safety Council (Hoskin, 1989) show that safety problems in bathrooms are becoming more pronounced. It can realistically estimated that at least several thousand fatal accidents take place in bathrooms every year. Without stronger procedural tools for coping with such problems, designers will continue to have little influence on that critical situation.

Framework of Threats to Safety and Health

How might existing practices be improved? Design is a cyclical process of analysis, synthesis, and evaluation. Analysis is the investigation of problems, the finding and the articulation of requirements to be fulfilled, and the assembling of data; synthesis entails taking the requirements and the data and inventing an appropriate design; evaluation checks the design against the requirements and provides feedback for future design. The general process of design is to break down the problem into its constituent and to solve each of these subproblems separately before attempting some grand synthesis. Thus, for a thorough understanding of the threats to safety and health, a general framework of threats and injury types is necessary.

There are differences in terms of level of abstraction at which design theorists treat the components of the safety and health problems. For example, Purdom (1971) categorizes environmental hazards as biological, chemical, physical, psychological, or sociological. McFarland (1973) categorizes injuries as mechanical, thermal, electrical, ionizing radiation, or chemical. On the other hand, Malven (1991) describes hazards as safety and health "threats", falling into one of seven categories: mechanical, thermal, electrical, chemical, organic, physiological, or emotional threats. According to Malven's general framework, the possible threats in bathrooms can be subdivided as follows:

1. Mechanical Threats
   * Falls onto/from elements
   * Bumps into objects
   * Cuts/punctures/crushing
2. Electrical Threats
   * Electrical burns
   * Electrical shocks
3. Thermal Threats
   * Fire product
   * Hot objects

* Hot liquids
* Hot atmosphere

4. Chemical Threats
   * Superficial irritation
   * Internal irritation
   * Allergic reaction
   * Cancer
   * Toxicity
5. Organic Threats
   * Infectious diseases
   * Building-originated infection
6. Physiological Threats
   * Skeletal-muscular stress
   * Cardio-pulmonary stress
   * Sensory stress
7. Emotional Threats
   * Interpersonal stressor
   * Environmental stressor

In this thesis, mechanical, thermal, and electrical threats are considered to be primarily threats to safety; chemical, organic, physiological, and emotional threats are viewed as threats to health (see Figure 1). But, threats and injury types almost unrelated to the bathroom environment are excluded from this thesis.

Safety

Definition of Safety/Accident

Safety involves more than just avoiding accidents. In fact, safety is not simply an end in itself; it is also a means to a more productive life. Sinnott (1985) defines "safety" as follows:

> "Safety of the person may be defined as a state of freedom from danger to health from accidents and diseases. In normal parlance safety means a reasonable degree of that state, it being recognized that absolute freedom from accidents and disease is impossible in everyday life."

Since it is practically impossible to eliminate all hazard completely, safety is a relative protection from exposure to hazards, a many-sided subject which draws upon interdisciplinary fields for its approach and content. In this thesis, the approach to personal safety is confined to designs that do what is reasonably possible to prevent accidents arising from the building environment, specifically bathroom. But it is difficult, as Sinnott (1985) points out, to delineate an area of safety without a generally acceptable, objective definition of accident.

English (1988) describes accident, in the technical safety engineering sense, as "an unintentional interruption of a process or procedure that may or may not result in bodily injury, and an event that is unforeseen, undesigned, and unlooked for and unexpected happening." The World Health Organization defines an accident just as an event independent of the will of man, caused by a quickly acting extraneous force, and manifesting itself by an injury to body or mind. Gowings (1962) defines the term as "a chain of events or series of interactions between a person's characteristics and the factors within his environment, which result in injury or economic loss."

Threats to Safety in the Bathroom

In this study, critical threats to safety are subdivided into mechanical, electrical, and thermal threats. Mechanical threats are the most common category of injuries in the built environment, including the bathroom.

Because moisture and pools of water--especially hot water--are present in the bathroom, electrical and thermal threats are more serious in the bathroom than in most other built environments. Such generalizations, however, do not adequately describe the impact of each threat on bathroom issues. Therefore, a separate description of each category of threats is in order.

Mechanical threats

Mechanical threats such as falls, cuts, and bumping into objects are the most frequent reasons for accidental injuries in built environment, especially in the bathroom. Primary injuries produced by mechanical threats are displacement, tearing, breaking, and crushing.

Falls. The most common type of nontraffic accidents are falls, which are the major reasons for serious and fatal bathroom accidents. Nearly every fall is a potential fatality, depending on how it occurs. In 1974, fatalities from falls in the U.S. numbered 14,000; just over half of which occurred in or around the home and 16 percent among people aged 65 to 74; 65 percent of all fatalities were people over 75 (Rush, 1981). There is general agreement among scholars that many personal

HEALTH, SAFETY, AND WELFARE OBJECTIVES: FREEDOM FROM...	THREATS TO SAFETY			THREATS TO HEALTH			
ENVIRONMENTAL (SOLUTION) COMPONENTS:	1. Mechanical Threats	2. Thermal Threats	3. Electrical Threats	4. Chemical Threats	5. Emotional Threats	6. Organic Threats	7. Physiological Threats
A. Site							
B. Structure							
C. Exterior Skin							
D. Drs/Wndws/Opngs							
E. Safety/Security							
F. Clim. Cont./Energy							
G. Plumb./Sanitary							
H. Sound Control							
I. Elec./Utilities							
J. Illumination							
K. Circulation							
L. Communications							
M. Information							
N. Walls/Partitions							
O. Floor							
P. Ceiling							
Q. Body Support							
R. Surfaces							
S. Storages							
T. Other Furniture							
U. Equipment							
V. Finishes							
W. Decor./Access.							
X. Other							

Figure 1. Systems definition of Health, Safety, and Welfare Issues in Interior Design (Reproduced from the source by Malven [1991])

and environmental factors combine to produce falls, but the manner in which those factors will contribute to any accident is unpredictable.

Fall accidents, according to Thygerson (1977), may be initiated by two different conditions. The first such condition is identified as the "loss of balance"; that is, the individual behaves so as to lose physical control of his or her posture. The second condition is identified as the "loss of support"; that is, an individual may retain postural control, but lose support from the environment upon which he or she depends. Sometimes, however, both of these conditions may be compounded in a single accident.

Falls, which occur with the highest frequency among the elderly, are far more common among elderly women. Azar and Lawton (1964) found that abnormal gaits are prevalent among elderly people, and that elderly women are less stable in their posture than elderly men and thus more liable to lose their balance. Elderly people in particular incur a high rate of accidental injuries and fatalities, with an accidental death rate more than twice that of the population in general.

Physical impairment is of obvious significance among elderly people. The high frequency of falls by old people has been attributed to deficiencies in the cardiovascular, skeletal, and central nervous systems (Over, 1966). Old people are more unstable in posture than young people are. Moreover, in an attempt to compensate for a reduced ability to use postural stimulation, old people place great reliance on the spatial framework provided by vision. Difficulties in maintaining a stable upright body position arise when minimal, ambiguous, or misleading spatial information is provided by vision. To illustrate, darkness often makes old people easily disoriented, and leads them into accident hazards. If visual information is incorrectly interpreted, falls may result unless there is correction through postural feedback.

Although the elderly suffer the most severe injuries, another age group is also particularly prone to falls. Around 40 percent of fall injuries are expected among persons younger than 15 years of age. In summary, special attention should be paid to bathroom planning for the safety of the 65 and over, and the 15 and under age.

One typical hazard patterns of fall accidents involves slipping and tripping. Slipping accidents occur when a victim is unable to react quickly enough to counteract change in body position. Sinnott (1985) describes slipping as follows:

> "Slipping on a floor usually occurs on a forward step as the rear edge of the heel meets the floor surface. At this stage of walking the other foot remains in contact with the floor, until the heel rocks forward and the leading foot is fully planted. The maximum force exerted forwards occurs shortly after the heel makes contact, it decreases as the weight of the body moves over the foot then increases to a maximum backwards as the ball of the foot starts to leave the floor. For slipping to be avoided, the friction between the sole-heel of the footwear and the floor surface must be sufficient to resist the maximum horizontal forces."

There are four fundamental factors causing slips and falls (English, 1988):

1. The coefficient of friction(COF) of the floor surface.
2. The COF of footwear.

3. Control of surface contaminants.
4. The walking style of individuals.

Among those factors, the COF of floor surfaces is the only one that interior designers can control. According to a survey by Department of Housing and Urban Development (Teledyne Brown Engineering Co. 1972, A-2), floors and flooring materials are the most hazardous fixture category; approximately 16 percent of injuries associated with floors are permanently disabling injuries. BOSTI (1978) lists examples of this type of accident:

1. Bathroom rug slips. Victim walking or stepping into bath puts one foot on rug, which slips on shiny floor surface, causing the victim to fall. While person is getting into or out of tub or shower, bathmat (inside the tub or on the floor) that is supporting one foot slips.
2. Floor surface changes. Victim moves from one flooring surface to another and his or her foot either slips or sticks, causing a fall. An abrupt change in floor surface friction can represent a slipping hazard. For example, while a person is standing in or getting out of the tub or shower, one foot slips on the tub/shower surface.
3. Friction force exceeded. Victim's foot slips on flooring when friction force is exceeded, causing a fall.

Tripping, as another cause of falls, comes about because the victim does not lift the feet, is not able to recover once a fall has started, or, with the greatest likelihood, is tired or in a hurry. Tripping happens primarily when a victim trips over uneven flooring materials. Examples of tripping accidents over rugs follow:

1. Floor surface changes. Victim, while walking, trips over the edge of rug at rug-to-floor junction and falls. Victim trips even though he/she can see the rug and is aware that it is there.
2. Unnoticed rug. Victim is in dark or unfamiliar surroundings and fails to perceive rug, trips on it, and falls.

Bumping into Objects. This type of accident, which involves the victim's bumping into objects in the bathroom and getting injured occurs less frequently than fall accidents. But bumping can cause secondary fall accidents. This type of bathroom accident can occur under a number of different circumstances:

1. Inappropriate situational model. Victim misperceives position of limbs in relation to object in bathroom and bumps into object.
2. Dark bathroom. Victim walking in dark bathroom is unable to see some object, bumps into it, and is injured.
3. Blackout. Victim suddenly loses vision or feels dizzy and falls in bathtub/shower or bumps into an object in bathroom and is injured (e.g., bumps into shower control and is burned by hot water). Often this occurs shortly after the victim has gotten up from bed.

Cuts/ Punctures/ Crushing. Most accidents of this type are related to doors and windows. Fingers are frequently injured in door-jamb and window-sash accidents, whose victims are usually young children. Most window related accidents are cuts by broken glass.

According to Teledyne Brown Engineering Co. (1972), doors have been involved in almost 25 percent of the overall total of home accidents annually. A great number of door-related accidents can be attributed to a combination of poor planning, design, and installation. Therefore a thorough consideration from the safety standpoint of the intended use of a door and its physical construction can significantly reduce the incidence and severity of door related accidents. Sliding glass doors, glass shower doors, and bathtub enclosures cause the majority of these accidents and account for most serious injuries, and many fatalities.

The BOSTI(1978) states that "fingers, hands, arms and heads are the most frequently injured body parts by door accidents. Generally, fingers are injured in door jamb accidents, resulting in contusions, abrasions, lacerations, crushing, hematoma or amputation. Hands and arms are injured in door glazing accidents, resulting in lacerations. Heads are injured in accidents involving door edges or faces, also resulting in lacerations."

Most injuries from window and glazing accidents are cuts; others are bruises and scrapes whereas the rest are amputations, fractures, and other injuries. Three-quarters of all such injuries are to the fingers, hands, and the lower arms. In most window accidents, the product involved in the injury was broken glass, whereas the movable sash edge injured around one fifth of victims (BOSTI 1978, p. 70). The causes identified with glass door/partition accidents are numerous:

1. incorrect glass type,
2. absence of markings on clear glass panels,
3. incorrect glass thickness,
4. improper installation (insecure glass),
5. improperly installed handles or absence of handles, and
6. extreme pressure required to open or shut the door

Accidents associated with windows frequently occur when children actively playing near windows, usually on lavatory tops in bathrooms, lose their balance and strike or fall through the window. Such accidents also occur when people try to perform a window-related activity such as opening, closing, and cleaning, or when they work in a window area while on unstable footing.

Tempered glass has the property, when broken, of creating very small granular shards with edges of lower lacerative capability than shards of broken annealed glass. Thus, tempered glass has the potential for entirely preventing or reducing the severity of most window related injuries.

Electrical Threats

Electrical threats can be categorized either electrical shocks or burns. In 1985, more than 900 Americans died from contact with electric current (Mansfield 1989, pp. 58-60). Accidents involving electrical devices account for approximately seven percent of the accidents related to fixtures in the home. Operating a radio or record/tape player while in the bathtub, or standing on wet ground and using power tools are but a few of the multitude of activities that can result in accidental electrical shock.

People can be fatally injured by as little as 60 milliamperes (0.060 amperes) flowing through their chest for one second (Teledyne Brown Engineering Co. 1972, p. 8-2). Primary injuries produced by electrical threats are neuro-muscular interference, coagulation, charring, and incineration, at all levels of body organization.

Until the advent of the ground-fault circuit-interrupter (GFCI), there had been no reliable method of protecting against fault currents too small to actuate fuses or circuit breakers. The GFCI provides protection against such faults.by monitoring the current flow in the hot wire and grounded neutral wire. As long as the current remains equal in both wires, no fault exists. At the moment the current in the neutral wire lessens to a predetermined value (often 5 milliamperes), indicating a flow of current to the ground through a person or any unintended conductor, the GFCI snaps off the power in as little as 25 milliseconds (Teledyne Brown Engineering Co. 1972, p. 8-2).

The National Electrical Code (NEC) requirement for bathrooms is the placing of one receptacle near the lavatory. Even though this makes plugging in electric appliances often used in the bathroom convenient, from a safety standpoint, it may seem unreasonable. But in making this receptacle placement a requirement, the NEC specifies that all 120-volt, and 15- and 20-ampere receptacles installed in bathrooms have GFCIs as a protective device. Such devices are available in three forms: one fits into the service panel in place of the standard circuit breaker; another fits into the receptacle box in place of the standard receptacle; the third simply plugs into the receptacle.

In the United States each year, about one million sunlamps are sold for use in the home, usually in the bathroom, and in the recently popularized tanning salons. Sunlamps are rich in ultraviolet radiation (UVR) and user can tan in less time than it would take them outdoors in the sun and maintain that tan year-round. But thousands of injuries from such lamps are treated in hospital emergency rooms each year. Most commonly, they consist of acute sunburn and photokeratitis, or inflammation of the cornea.

Thermal threats

The thermal threats in the bathroom consist primarily of burns, mostly by hot water, radiators, or exposed heating pipes. Hot water burns can occur in the bathroom probably more frequently than in any other area of a home, except around the kitchen range. The Consumer Product Safety Commission estimates that some 2600 people are injured in the home each year from tap-water scalds (Rush 1981, pp. 122-123). Thermal injuries can be classified as first, second, or third-degree burns, with specific result depending on the location and manner in which the energy dissipates. Primary injuries produced by thermal threats are inflammation, coagulation, charring, and incineration at all levels of bodily organization.

Burning hot water can cause severe burns within three seconds. Water heated to 115° Fahrenheit or above is the practical limit of human skin tolerance and therefore destructive to human tissue. Only two seconds in 150°F water is needed for a third degree burn; this takes six seconds in 140°F water, and thirty seconds in 130 F water (Rush 1981, p. 122). Water temperatures relative to human contact are experienced as follows (Teledyne Brown Engineering Co. 1972, p. 3-7):

Below 65°F	Cold
65 to 90°F	Cool to Tepid
90 to 98°F	Warm
98 to 105°F	Hot
105 to 115°F	Very hot
115°F and Above	Destructive to Human tissue

The threat of gushing hot water to infants and small children is monstrous as a cause of death and disfigurement. Even adults can suffer, especially when a too narrow shower pipes cause a sudden rush of hot water when the cold water is turned on elsewhere in the house, or when a victim is unable to control water temperature because he/she misjudges the position of the temperature control or does not understand how the control works. In addition, falls or injuries from quick reflex actions can occur, regardless of actual water temperature, when the experience is totally unexpected.

Therefore, the inconvenient location of hot and cold water controls in tubs and showers can cause severe burn accidents and secondary fall accidents. To avoid these hazards, the National Safety Council recommends mixer faucets with thermostatic valves for bathtub, shower stall, and lavatory. It is essential to choose reliable water fixtures that adjust to desired temperatures quickly and accurately. Lowering the setting of the water heater and/or installing a mixing valve that will prevent unexpected water-temperature changes are other means of alleviating the threat of burns.

Health

Definition of Health

The term health in the widest sense includes comfort and a feeling of well- being. Grandjean (1973) stated that if one's comfort is lessened by annoyance and other forms of subjective disturbances, it is of as much fundamental importance as direct damage to health. The World Health Organization defines health as a state of complete physical, mental, and social well-being, not merely as the absence of disease or infirmity. Disease is described by Rush (1981) as a long-term attack on the body by the destructive elements of the environment. The term environmental health can be used, according to Purdom (1971), to encompass human health and well-being, including freedom from illness, health maintenance, human efficiency, comfort, and the enjoyment of life. Building-related diseases include infections such as Legionnaires' disease and hypersensitivity diseases such as pneumonia, humidifier fever, asthma, and allergic reactions.

Threats to health in the bathroom

In any room used by people, the air is altered or contaminated in the following ways: dust and smells, water-vapor, heat given off into the air, production of carbon dioxide and reduction of oxygen, contamination with bacteria, contamination from outside or as a result of processes taking place in the room, etc. (Grandjean, 1973). As the bathroom is usually a closed environment and the most humid place in a building or a house, the threat to health is great. Unlike safety problems, health problems in the bathroom, such as respiratory ailments or allergic reactions caused by fungi and bacteria are generally intangible and invisible.

In this study, threats to health are subdivided into four categories: chemical, organic, physiological, and emotional.

Chemical threats

Man's reaction to a chemical depends upon its toxicity, the individual's susceptibility, the duration of exposure, and the chemical concentration. The effects of chemical intoxication can be localized in the lungs or on the skin, or they can be systemic, after translocation throughout the body via the blood or lymph. Allergic reactions and irritations may occur upon chemical contact, depending up on individual sensitivity. The symptoms of chemical intoxication can be sensory irritation of eyes, nose, or throat--including hoarseness or changed voice--skin irritation or reddening, and, in nonasthmatic persons, asthma-like symptoms such as runny nose or eyes.

The number of people exposed to chemical contaminants at low levels is much greater than the number exposed at levels high enough to produce overt responses. Furthermore, low-level exposures are often continuous or repetitive over periods of many years. In fact, the chemical threat posed by the bathroom is usually of the continuous and repetitive low-level exposure type.

Among the toxic substances encountered through breathing are chemically active dusts, gases, and solvent vapors. Some chemical substances, particularly solvents, may be absorbed through the skin. Typical sources of chemical pollution in bathrooms are as follows:

1. Aerosol sprays: hair sprays, tints, dyes, shaving creams, deodorants, antiperspirants, etc.;
2. Building materials: fiberglass linings, asbestos products, adhesives;
3. Emissions from heating and cooling devices: gas or oil furnaces, fireplaces;
4. Germicides and disinfectants; and
5. Smoking.

Asbestos. Asbestos can be defined as well-developed, thin, long-fibered varieties of certain minerals. Commercial uses of silicate mineral fibers described as asbestos have been extensive, including floor tiles, asbestos cements, insulating materials applied pipes, boilers and tanks, and other equipment. According to Godish (1989), asbestos products presenting the greatest concern are those of a friable nature sprayed or troweled on walls, ceilings, other structural components, and insulation. Friable asbestos applications include fireproofing, thermal insulation, acoustic materials, and decorative surfaces. Even though most of the uses of friable asbestos were banned by the U.S. Environmental Protection Agency in 1978, pre-existing or used asbestos applications can be the source of potentially serious indoor contamination.

The human health hazards of asbestos are well known: four diseases have been clearly associated with exposure to asbestos: lung cancer, mesothelioma, asbestosis, and nonmalignant pleural disease. Public health concern related to nonoccupational asbestos exposures is focused on lung cancer and mesothelioma.

A variety of source control options are available to reduce exposure to asbestos fiber. To prevent or reduce the likelihood of asbestos fibers becoming airborne or resuspended, Godish (1989) suggests four building operation and maintenance practices: repair; enclosure; encapsulation; and removal.

Combustion-generated pollutants. It is not hard to find fireplaces or space heaters in somewhat spacious and luxurious residential bathrooms, or to find persons smoking while they use the bathroom. But heating appliances and tobacco smoke are typical sources of combustion-generated pollutants. A variety of heating appliances, including wood stoves, furnaces, fireplaces, and gas space heaters, may cause significant indoor contamination. Elevated levels of CO, NO, NO_2, SO_2, and particulate matter during the period of appliance operation have been reported by many researchers. Various gaseous and particulate-phase materials are produced as a result of tobacco smoke. Some of the significant compounds or materials associated with tobacco smoke are respiratory particles, nicotine, CO, CO_2, formaldehyde, and benzene.

Because carbon monoxide is odorless and tasteless, CO produced by the incomplete combustion of fuels from heating equipment, especially in confined spaces such as bathrooms, can also be dangerous to the person who is relaxed and falls asleep in a bathtub or chair. A variety of health effects have been associated with CO, ranging from neuromotor effects such as decreased attention span and reaction time, to headache, nausea, extreme drowsiness, and even death by asphyxiation.

Elevated combustion-generated pollutants in indoor spaces usually result from unvented, improperly vented, or poorly maintained appliances and from tobacco smoke. Proper ventilation, either by natural ventilation through windows, by mechanical ventilations, or a combination of these two methods, is definitely necessary to eliminate the pollutants. But, when designers consider mechanical ventilation systems in airtight, energy-efficient bathrooms, they have to check the possibility of significant depressurization of the space, which can cause the suction of decayed airborne pollutants from drainage into bathrooms.

Formaldehyde. Formaldehyde is distilled from various building materials and furnishings, especially from various kinds of adhesives such as carpet adhesive and plywood or particleboard glue, as well as from insulation made with urea-formaldehyde foam. The hazardous health effects of formaldehyde exposure in indoor spaces fall into three basic categories: irritant effects, sensitization and asthma, and carcinogenicity. Formaldehyde is a strongly irritating gas, leading to burning eyes, congested sinuses, and inflamed respiratory passages.

The most effective method of lowering indoor formaldehyde levels is to remove the sources from the building environment or to avoid using materials emitting great quantities of formaldehyde. But one of the major problems with the latter approach is that it limits consumer choice to products that may be more expensive and/or aesthetically less appealing. Surface-applied aftertreatments that can be applied by roller coaters, laminating or coating on one or both sides of particleboard for furniture or cabinets, applying alkyd resin paint and vinyl wall paper, and ammonia fumigation are potential solutions to the health problems posed by formaldehyde.

Others. Insecticides, antimicrobial agents, room fresheners, and toilet bowl deodorizers may also contaminate indoor air with various volatile organic compounds such as chlordane, heptachlor, and pentachlorophenol, which are all potentially carcinogenic.

Organic Threats

It is quite difficult to determine exactly what kinds of diseases are caused by the bathroom environment. The extent of health problems caused by organic contaminants in the indoor environment is difficult to estimate, partly because of the broad array of micro-organisms evoking human responses, and partly because of the broad range of environments possible. But, it is generally accepted that many micro-organisms and their spores, as Grandjean (1973) notes, grow and float in the air of bathrooms, where there is a high concentration of water vapor, thereby causing various allergic illnesses.

Airborne micro-organisms cause a substantial share of infectious disease incidences, especially in indoor environments. Pathogenic bacteria, viruses, amoebae, algae, fungi, spores, mites, and molds are responsible for a wide variety of diseases including allergies, asthma, and hypersensitivity pneumonitis/humidifier fever as well as Legionnaires' disease. Allergies and asthma are the two most common disease syndromes associated with airborne particles of biological origin. About 20 percent of the population have the genetic predisposition to produce antibodies in response to exposure to spores, microbial cells, animal dander, and bug parts, a phenomenon resulting in allergic reaction. Spores of fungi can become airborne by active processes. Bacteria and viruses become airborne in aqueous aerosols formed by a variety of processes, including sneezing and coughing, and spraying of sewage in treatment and disposal.

Teledyne Brown Engineering Co. (1972, p. 7-4) reported that "some disease-causing bacteria survived even after the carpet had been thoroughly cleaned and disinfected; germs were discovered in 'clean' carpet that had been in storage 20 weeks in a completely sterile container; fungi that cause ringworm and athelete's foot were found in carpet that had been scrubbed with a germicide and stored for periods of up to eight months."

Because any source of carbon provides nutrients for microbial growth, the dust and debris adhering to moist, rarely cleaned surfaces provide ideal sites for fungal amplification. In bathrooms, many micro-organisms grow on damp walls, wet carpets, inadequately maintained parts of HVAC systems, and corners and nooks difficult to clean. Their spores float in the air of the room and cause allergy-related illnesses such as asthma, allergic inflammation of the respiratory tract, and skin diseases.

Mold. Mold spores and hyphal fragments, which are the causes of allergies and asthma, are typically dispersed by air currents. Mold spores can be inhaled and deposited on sensitive respiratory tissue and consequently cause mold allergies. There is a positive association between fungal prevalence and relative humidity; the prevalence of mold in indoor environments can be related both to building moisture levels and to water-damaged materials. Mold spores require a relatively high humidity to germinate. According to Godish (1989), minimal levels are on the order of 70%. In bathroom environments, mold growth may occur on walls, carpeting, ceiling tiles, shower curtains and tiles, furniture, storage boxes, etc. Especially high mold levels have been associated with jute-backed carpeting repeatedly wetted by bathroom spills, and with the lack of sufficient exposure to natural light. Avoidance of mold allergies and of asthmatic conditions caused by mold contamination can best be achieved by maintaining a relatively dry environment, admitting abundant natural light, and preventing condensation on indoor surfaces.

Dust mites. Dust mites are arachnids that consume the skin scales of humans and other animals. Mites thrive in damp dust and can cause allergic diseases of the respiratory tract. They are, in fact, probably one of the most important causes of asthma in North America, as well as the major cause of common allergies. Ordinarily, those micro-organisms require moisture, a food medium, and proper temperature and PH to survive any length of time. One of the major limiting factors in mite survival and population development is the availability of water for absorption. A strong dependence on indoor relative humidity levels has been observed for dust mite populations; consequently, drying is the easiest way to kill those micro-organisms.

Physiological Threats

Physiological threats are defined by Malven (1991) as the stressing of a human physical system beyond its normal limits. He classifies physiological threats as skeletal and muscular, cardio-pulmonary, or sensory stresses.

Skeletal-muscular Stress. Skeletal-muscular stress involves, according to Malven, the straining of bones, muscles, or connective tissues beyond their normal capacity. Many physiological threats are related to this stress. For example, injuries are sustained while attempting to operate windows which are hard to move. Locations, heights, and sizes of fixtures, and their distances from grab bars, lever handles, water controls, etc., are all features closely related to skeletal-muscular stress. Thus, most dimensional data from ergonomics are quite helpful in releasing skeletal-muscular stress.

Cardio-pulmonary Stress. As an abnormal strain on circulatory and respiratory systems, cardio-pulmonary stress can result in discomfort and pain. For example, toilet seating has an impact on cardio-pulmonary functioning. According to Kira's research, toilet and bidet design, especially seat design, effects the user's posture and applies pressure to ischial tuberosities. With a conventional seat, the body weight is largely borne by the thighs, tissues are compressed, and, in addition to some potentially injurious effects to muscles and nerves, considerable discomfort results (Kira, 1976, pp. 120-126). Thus, modified seats distributing body weight over as much surface area as practical are highly recommended. Rounded "water fall" edges and resilient padding optimize the relation between mobility and freedom from pressure in seating (Malven, 1991).

Sensory Stress. Sensory stress includes temperature, humidity, air movement, illumination, eye strain, color, etc. Temperature and humidity are important to efficient human performance. The critical air temperature for human, according to Purdom (1971, p. 16), ranges from 1 to 32°C (32°F to 90°F), and their thermoneutrality zone is 24°C-31°C (75°- 88°F). When people are exposed to air temperatures below 60°F, their reaction time increases whereas their manual dexterity and tactile sensitivity are decreases. Cold and damp rooms are bad for rheumatics.

The chilling of particular body parts (knees, hip-joints, elbows) lowers resistance and encourages acute rheumatism. Relative humidity has very little effect on effective temperature as long as the air temperature is within the comfort range. But this does not mean that relative humidity has no effect on well-being and health. Most people find a relative humidity of 40-45% comfortable during the period when heating is needed. Values greater than 55-60% easily give rise to condensation, and below 30% the air is regarded as too dry (Grandjean 1973, p. 183).

Air movement is also critical in terms of sensory stress. Data from the ASHRAE Guide and Data Book (1972) indicate that velocities less than 15 ft/min generally cause a feeling of air stagnation, whereas velocities higher than 65 ft/min may result in a sensation of draft. Other literature (Grandjean, 1973) suggests that in most European countries air velocities of more than 0.2 meters per second(40 ft/min) are regarded as unacceptable for seated persons; for very delicate sedentary work, a limit of 0.1 meters per second (20 ft/min) is recommended. Generally, air motion in the range of 20-40 ft/min is considered acceptable.

Illumination in the form of daylight and sunshine makes a room dynamic. Environmental lighting exerts important effects upon human health and productivity, far beyond its requirements for vision, because sunlight includes ultraviolet and infrared as well as visual light. At their natural levels of radiation, these components have essential disease-preventing effects and properties. Such effects include both synthesis of vitamin-D and maintenance of normal biological rhythm. Sunlight can lower our blood pressure and may even reduce the level of cholesterol in the bloodstream; it triggers internal processes affecting blood, bones, protein level, and numerous glands and organs; it can increase our resistance to a number of diseases and even cure them.

Improper illumination can be a predisposing factor to "accident" in the sense that poor illumination makes it impossible or unlikely for humans to get the necessary information to remain safe. Color vision is possible only in light levels greater than that provided by the full moon. Signs or similar devices that depend upon color to achieve their purpose must either be seen in good light or have some other means of coding the same information, such as shape coding.

To function properly, the eyes require constant variation in light source. Without change, the pupils do not respond normally, and consequently, eyestrain is inevitable. Eyestrain can cause headaches, dizziness, and a nauseous feeling. Abrupt changes in lighting levels, glare, visual masking, and insufficient illumination, however, can cause confusion and accentuate all of the hazards leading to accidents. Glare occurs when a bright object is placed in the visual field within 60° of the line of sight (Grandjean, 1973). Glare, either direct or reflected, can cause visual fatigue and poor performance, thus increase the likelihood of mishaps.

Emotional Threats

Privacy. Emotional/psychological threats are just as important as the chemical, organic, and physiological threats in terms of the development of positive health and the prevention of disease. When we think of emotional threats in the bathroom, privacy immediately comes to mind. Privacy is an excluding process, one of being alone or of getting away from others. Even though the bathroom is still the most private space, but because today's bathroom, especially the family bathroom, has a tendency to become a multi-functional space--inevitably to be shared with others--the concept of privacy in the bathroom, thus, should be treated differently as compared with the traditional approach to providing maximum isolation.

Kira (1976) divides privacy into three levels: privacy of being heard but not seen; privacy of not being seen or heard; privacy of not being seen, heard, or sensed; this last category means that other people should not even be aware of one's whereabouts or actions. Those different levels of privacy are directly related to the specific bathroom fixtures being used. From that viewpoint, probably the toilet needs the highest degree of privacy, the bathtub next, and so on.

Actually, noise, lack of visual and acoustic privacy, lack of open space, and boredom are some of the emotional threats to be considered. The symptoms from those emotional threats include anxiety, mental fatigue, reduced power of concentration, and claustrophobia.

Providing acoustical privacy is essential in bathroom design. Most people require a great degree of acoustic isolation from others, because, as Kira (1976) explained, bathroom sounds tend to be pronounced, easily identifiable, and hence a cause of intense embarrassment--both to the originator of the sound and to any listeners. Practically, privacy booths, instead of attempting to acoustically treat the entire bathroom, can be designed to screen out potentially embarrassing noises. Alternatively, noise can be rendered unintelligible to others through masking. As Miller (1985) points out, mandatory vent fans installed in bathrooms without windows are typically switched on, not for ventilation, but for masking bathroom noises. White-noise machines or music tapes can also be activated during bathroom use. Furthermore, machine or tapes should be activated each time the room is used, whether for private activities or not, because, if the white noise or music is turned on only when acoustic privacy is desired, a clear signal is sent to others that private activities are taking place. Then privacy may still be violated. Typically, hydromechanically originated sounds such as flushing or cistern refilling, ranging from 70 to 80 dB for a standard wash-down water closet, can be one of the major intelligible sound that people wish to mask. Flushing noises result from bowl design and depend upon efficiency. Among various types of water closets the siphon-action water closet is the most efficient and the quietest style up to date.

Windows. Among design components, the window is most intimately related to emotional threats. Pleasantness and enclosedness, among the psychological dimensions of buildings identified by Küller

(1972), are meaningful in considering psychological comfort in bathroom window design.

Windows provide several tangible functions and benefits in addition to fresh air and lighting. One of the relatively unexploited aspects of windows in bathrooms is the possibility of sometimes having spectacular views to enjoy. Windows provide a view out, yielding some contact with the outside world, and adding a dynamic, active quality to an interior environment. They also furnish instant information of the weather, the time of day, and changing events in the external world. Additionally, daylight has a more pleasing and natural character than artificial illumination. The window affects most the people's perception of themselves. Causing a room to appear more spacious, it makes people feel better, as manifest in their increased body boundaries. The window offers the possibility of a brief respite or momentary escape from somewhat undesirable surroundings (Collins 1975, pp. 34-36). For some, windows can supply relief from feelings of claustrophobia, monotony, or boredom. In a small room like a bathroom, windows allow an opportunity for a change in focus or a visual rest center.

The distance from the window affects people's satisfaction with the view. The information content of the view is critical in determining a person's satisfaction with a room's windows. To maximize this content, Marcus (1967) recommended vertical windows providing information about three layers: the sky (upward), the city-scape (horizontal), and the ground (downward). In addition, he suggested that a good view should provide a certain amount of dynamic change.

The "just acceptable spaciousness" of a room is determined by its volume and by the presence of windows (Inui and Miyata, 1973). Kira (1976) also found out many of survey respondents had indicated a desire for considerably larger windows than those commonly found in bathrooms--probably to provide better light and ventilation. Code provisions usually require a window area of from one-eighth to one-tenth of the floor area and specify that 45- 50% of that area should be openable. Window size and shape has a great effect upon perceived spaciousness. One study indicated that square-like rooms appear more spacious with a continuous window on the short wall (Collins 1975, p. 75). Moreover, this effect seemed to increase for a window at eye level. Other factors found to increase the spaciousness of a room were increased sky luminance, and room volume.

A windowless environment should not be considered as only design solution for energy conservation. Energy waste can be reduced through sensible design: double or triple glazing, special solar glasses, shading devices, natural vegetation, building orientation, etc. A windowless situation also occurs in residential dwellings in which rooms such as bathrooms or kitchens are located in the center of the building, away from external walls. The length of time spent in a windowless environment may be important. A survey of residential buildings however, has found a quite unfavorable reaction even to the limited use of windowless bathrooms (Collins, 1975). It is generally accepted that windows can provide an excellent means of escaping from a building fire, even though they may not be the preferred exit. Additional demerits of windowless buildings or rooms from a safety standpoint result from their total reliance on artificial illumination and ventilation systems.

Natural and Artificial Lighting. Natural sunlight has a pleasing psychological effect. The study of photobiology indicates that people have psychological as well as physiological requirements for illumination. Milsum (1984) states that natural light positively affects our neuroendocrine systems, reporting a direct "energetic pathway" into the hypothalamus and pituitary gland, and therefore into our stress-response system. Spectral coloring can also have important effects, and specific colors tend to elicit specific moods. One survey investigating people's preferences regarding sunlight reveals that people were more concerned with its tonic effect than with the physical factors of warmth and light.

Natural daylight indoors is little affected by the direction in which the window faces the sky, whereas the same factor has a critical effect on the length of time that sunlight can penetrate. Even north-facing rooms can receive plenty of daylight as long as the area of the window and the angle of view are suited to the size of the room.

Research by Hollwich (1979) and others discovered that the full-spectrum light (FSL), which closely represents the wavelengths present in sunlight, has some effects on people's feeling of stress and their behavior. Ordinary artificial lighting, however, is not full spectrum, and stressful effects, especially of fluorescent lighting, are reported in that study. Hollwich (1979) discovered that even when people are exposed to continuous high-intensity levels of FSL, the stress reactions occurring with a similar regular lighting design do not appear. Other research has revealed that under FSL in the factories, accident rates decrease. In a school setting, children achieve more, and there are significant decreases in hyperactivity and other behavioral problems.

Color. It is generally accepted that color has some direct psychological influence on people, such as changes in blood pressure, respiratory rate, and reaction time (McCormick and Sanders 1987, p. 534). Generally speaking, people tend to prefer light colors to dark colors and saturated colors to unsaturated colors (McCormick et al., 1987). Color affects the spaciousness of room, with dark colors having a depressing effect, making a room look small, and making it difficult to keep clean. As Grandjean (1973) described, bright colors are usually friendly; they reflect light, brighten the room, and encourage cleanliness.

Noise. A noise, a primary environmental hazard, is commonly defined as any unwanted sound. Noise can affect the neurological, cardiovascular, and endocrine systems, which are typically active in a general stress reaction. The disturbance evoked by noise depends up on various components, partly associated with the nature of the noise itself and partly with the situation. Among the important factors Grandjean (1973) describes the most important one related to the bathroom environment is the people's reaction to noise, and individual sensitivity. Whether the person is bathing, grooming, or eliminating is a decisive parameter of disturbance from noise. The same person can react quite differently to the same noise under different circumstances.

While a threat-based definition of environmental hazards provides a useful framework for conceptualizing safety and health problems, the actual agents of injury in bathrooms and other spaces are their physical components. Thus, more specific attention needs to be focused on the role of these components in the creation of safe and healthy bathrooms.

Design Component Analysis

Design Influences on Threats

Design may be considered a search process in a space of alternative solutions, the seeking of one or more solutions that can satisfy certain design criteria. Designers should be solution-oriented. To arrive at satisfactory solutions, they should fully understand and analyze the causes of problems before seeking solutions.

Many of the accidents frequently occurring in the bathroom are due as much to facility design as to user error. Therefore, to prevent accidents, Cliff (1984) states that causes of accidents should be fully understood and then, actions should be taken to reduce the risks of potential accidents. Secondarily, if the primary objective of preventing accidents seems unattainable, the next objective in relation to accident prevention is to prevent or reduce the severity of injuries when accidents do occur.

Involvement of design components in the accident process

Van Erdewijk (1988, p. 166) discusses the kinds of involvement of design components in the accident process:

1) Constituent parts of dwellings contribute directly to either the cause or the injury, but not both. For example, a slick floor may cause a fall, but the injury results from striking the toilet.
2) Some parts of dwellings make a direct contribution to both the cause and the injury related to an accident. For example, a slippery floor causes a fall accident, and the victim's impact with the floor causes the injury.
3) Some parts of dwellings are secondarily involved in accident processes. An accident and injury would have occurred without them, but their failure exaggerates the problem. For example, the injury of a person falling down a hazardous stair is more serious because the handrail used to "break the fall" was loose and failed to do so.

Van Erdewijk's analysis can be directly adopted to analyze each design component in the bathroom. Actually, the safety and health implications of most design components can be listed under one or more of his categories.

Based on the foregoing principles, and Malven's systematic method of subdividing an environment (Malven, 1991), the bathroom can be subdivided into a number of design components (see component headings in Figure 2). In the following section, information related to each design component is summarized. But to avoid overlapping, most information described in the illustrated data units (Chapter IV) has been omitted in the following overview.

Bathtub/shower

From a "task sequence" analyzing the steps involved in using tubs and showers, slips, falls, and "bumping" accidents are the most frequent causes of injury for persons using tubs/showers. Most of these accidents occur when an individual is engaged in the tasks of getting into the tub/shower, cleansing the body, changing position in the tub or shower stall, or getting out of the tub/shower. Successful performance of these tasks involves the ability (1) to execute a range of movements in a confined space, (2) to maintain body balance, (3) if body balance fails, to react quickly enough, with sufficient force, to regain body position. The BOSTI(1978) reported that bathtubs far exceed shower stalls in accident representation in terms of both frequency and severity of injuries. The slipperiness of bathtub surfaces constitutes the major hazard and the hardness of bathtub surfaces is the chief agent of injury. Causes associated with tub and shower accidents are:

DESIGN COMPONENTS	THREATS TO SAFETY 1. Mechanical	2. Thermal	3. Electrical	THREATS TO HEALTH 4. Chemical	5. Emotional	6. Organic	7. Physio-logical
A. Bathtub/Shower							
B. Floor							
C. Circulation/ Accessibility							
D. Lavatory							
E. Toilet/Bidet							
F. Window							
G. Ventilation							
H. Door							
I. Grab bar/Handrail							
J. Natural Lighting							
K. Artificial Lighting							
L. Electricity							
M. Color/Pattern							
N. Wall/Partition							
O. Other							

Figure 2. Framework of threats in the bathroom

1. slippery surfaces
2. improper materials
3. lack of handholds
4. improper height of tub/shower
5. improper installation of grab-bars
6. faulty faucet
7. improper installation of soap containers
8. sharp edge of tub enclosure
9. improperly placed towel rack
10. inadequate natural or artificial light

The height of tub/shower is directly related to the bathroom accidents and physical strains. For example, if the side of the tub/shower is too high, people are forced to sit on the side of the tub and swing their legs over to enter--a procedures which is unsafe and uncomfortable. On the other hand, bathtubs set too low are difficult to clean and make bathing children difficult. Also, the steps leading up to the edge of tubs, prevailing fashion of today's bathtub designs, are inconvenient, uncomfortable, and unsafe even if there were a hand-grip, because there is absolutely no way anyone can safely enter or leave such an installation (Davidsen, 1989).

To prevent accidents and to provide convenience, faucet sets in bathtub/shower combinations should be mounted at convenient locations according to anthropometric data . Even though the misplacements of faucet sets cannot be the primary cause of accidents, they are often identified as the secondary cause.

Burns, drownings, and electrocutions occur less frequently than slips and falls, but are usually more severe accidents related to the tub/shower. Most of the victims of tub/shower accidents are children. Even though elderly people rank second in terms of the frequency of such accidents, their injuries are generally the most severe.

Floor

Bathroom floor surfaces in particular tend to be very slippery, especially when wet. Most of the accidents related to bathroom floor are slipping and tripping accidents. Among the major causes of floor accidents are inappropriate materials, abrupt changes in floor surface friction, unexpected floor level changes, and uneven materials and joints. Whenever possible, the use of a consistent material for a bathroom floor is recommended. One-step level changes should not be employed. If inevitable, a level change should be clearly visible (BOSTI, 1978).

Assuming that occasional accidents are inevitable, bathroom flooring should be of materials that can reduce the severity of injuries. Floor materials should be soil- and moisture-resistant because wet floor conditions, especially in conjunction with carpets, raise health issues such as organic contamination.

Circulation/accessibility

Bathroom safety is influenced by general planning factors such as the size and shape of the room, the position of windows and doors, the space for movement past individuals or fixtures, and the space for cleaning between opposite and adjacent fixtures or walls. Many activities occur in the bathroom requiring more than the basic space needs for the simple use of fixtures. Dressing and drying one's body require perhaps the largest clear activity space. For example, a minimum free floor space of 2 feet, 6 inches by 3 feet, 6 inches is required for dressing. But this area may be overlapped by the free floor space required in front of other fixtures.

Bathroom layouts should be designed to provide adequate room for various activities, as well as a hazard-free area. Doors are particularly related to accidents caused by lack of space. Placement of doors and their swinging directions should be carefully considered.

Lavatory

Among bathroom fixtures, the lavatory is the most frequently used fixture for personal hygiene and grooming and body care activities. Adequate counter height, space, elbow room, and clearance space between the lavatory and the opposing wall are critical issues to avoid hitting body parts against walls or other fixtures. Most of these criteria should be based on ergonomics to reduce physiological stress.

The lavatory surface should be impervious to water, easily cleanable, and sanitary. Thus, molded integral sinks, because they have no joints, are recommended.

Toilet/bidet

In the space around the toilet and bidet, victims may slip, fall, and strike nearby fixtures, often injuring their heads. Users may also bump into other fixtures or walls if enough free space is not allowed.

Types of toilet and bidet units are closely related to safety and health issues. For instance, wall-hung types allow for easier floor cleaning and eliminate the toe stubbing base of floor models. The flushing actions result from bowl design and differ in terms of noise generated and efficiency. A toilet with a quiet flushing and refilling mechanism reduces emotional embarrassment. From this perspective, siphon-jet or siphon-action types are preferable to wash-down or reverse-trap types.

The height of the toilet is often critical for the handicapped or the elderly. Unfortunately, the standard toilet height is usually too low for them. Thus, Harkness (1976) recommends either adjustable-height toilet seats, or a height of 18 inches for both the disabled and able-bodied, even though the compromised height is not adequate for children.

Window

Window design in the bathroom is related to the overall threats to safety and health. Natural ventilation, brightness, direction of natural light, viewing, temperature and humidity control, and psychological spaciousness are some of the bathroom-window related factors that should be considered. Along with psychological effects, natural sunlight through windows provides diverse benefits such as drying out walls, killing micro-organisms, and reducing heating expenses.

Window locations and sizes affect the arrangement of bathroom fixtures. Proper planning for window placement and type can reduce or eliminate physical accidents and psychological stress.

Ventilation

In terms of ventilation, design and operational criteria are based upon the environmental quality to be achieved, as required for health, comfort, and safety of the occupants. The basic reasons for ventilation are to provide clean, oxygen-rich air for breathing; to remove odors, humidity, and harmful micro-organisms; and to cool.

The ventilation process consists of air entering a building through one or more inlets, such as vents, windows, doors, etc., and escaping through outlets. The number of apertures within a space without cross-ventilation is very important because the apertures can be subdivided into inlets and outlets or be partially both inlets and outlets having a considerable effect on the interior velocity of the air. Melaragno (1982) reported that the shape of the inlet can have a pronounced effect on the interior velocity, especially when cross-ventilation is missing. Baffles installed on the side of windows, for instance, can improve the ventilation considerably. The height of inlets and outlets above the floor of the space to be ventilated greatly influences the effectiveness of ventilation. The most efficient ventilation, according to Melaragno, occurs when the inlet is low and the outlet high above the floor. In that case, the air current crosses all the air layers, envelops the occupants, and rises, gradually pulling out the warm air near the ceiling. Rodahl (1986) has the same opinion. He states that sources of pollutants are quite often warmer than the surroundings, and in such premises, it is favorable to supply fresh and cold air from below. But Walter (1988) suggests that, when it is necessary to depend totally on mechanical ventilation, the air should be diffused from supply fixtures at the ceiling and exhausted near the floor to ensure proper dilution of the microbiologic, allergenic, and chemical contaminants.

The ventilation techniques generally used in bathrooms are natural ventilation through windows, including skylights, and forced ventilation with extractor fans. But Kira (1976) warns that the common, simple device of opening a window in the bathroom is often unsatisfactory because of the nudity: first, there is often a marked loss of privacy; second, there is the danger of cold, annoying drafts. To avoid the latter problem and to provide adequate ventilation under all circumstances, a mechanical vent system is generally preferred. Additionally, extractor fans can provide adequate masking sound to bathroom users. But natural ventilation through well-designed windows is preferable emotionally, physiologically, and economically.

Door

Door accidents are most frequent among children less than 13 years of age (BOSTI, 1978). Most of such accidents are the result of the acts of others or of performance errors on the part of the victim. The placement of doors and their hardware fittings frequently result in caught fingers of small children; the direction and amount of door swing are also important in planning for safety. Poor planning that allows conflicting or interfering door-swing conditions can cause accidents. Usually, the door should swing into the bathroom, preferably into an out-of-the-way area. It is desirable to swing the door against a wall to eliminate the chance of striking an individual using one of the fixtures.

Sliding glass bathtub and shower doors are frequent causes of accidents. The extreme slipping potential which exists in the use of tubs and showers, combined with the limited space within these enclosures, increases the probability of serious injury if glass is part of the tub or shower partitions. The use of safety glazing is the most effective alternative to prevent accidents or at least to reduce the severity of accidents. Tempered glass, laminated glass, wired glass, and the substitution of glass with a variety of acrylic plastics are typical types of safety glazing. An enclosure door with a locking type latch may also prevent or delay an exit or entry in cases of emergency, and should be avoided.

Most bathroom doors swing into the bathroom. But for the handicapped and the elderly, doors to the bathroom should not swing into the bathroom, for two reasons:

1) The space taken by the swing of the door will interfere with the needed free space for maneuvering a wheelchair.

2) In case of emergency, an unconscious body lying next to the door will make entry difficult; so a pocket door could be one of the possible solutions (Raschko, 1982).

Grab-bar/handrail

Grab-bars and handrails should provide substantial support and convenient assistance capabilities for a wide range of user requirements. These fixtures are important for maintaining balance, stability, and safety, and to prevent and recover from falls.

Misshapen or misplaced grab-bars and handrails , or failure to install either where it is needed for level changes or body-support can cause accidents. Positioning the grab-bar and shaping it in such a manner as to permit a full power grip should be considered in bathroom design, especially in the bathtub/shower for the elderly or the disabled. For example, allowing the hand to encircle the railing allows about four times the force than if only a pinch grip or an incomplete grasp is allowed. Different positions are for different functions: horizontal grab-bars for pushing up; vertical grab-bars for pulling up. Additionally, as people are predominantly right-handed, placement of the handrail is important. The average individual's coordination, strength, and ability are in his right arm and hand. Because the fall accident potential is greatest on descent of a level change or inside bathtubs or shower stalls, single handrails should be placed on the right side, descending; grab-bars on the right side toward shower heads or controls are also preferred.

Grab-bars should be circular, oval, or oblong in cross section, because rectangular handrails do not allow a power grip (Rush, 1981). To provide maximum power grip, the diameter of cylindrical grab-bar should be no less than 1.4 inches and no greater than 1.65 inches. A grab-bar, $1^1/_2$" in diameter, installed with $1^1/_2$" clearance between the bar and the wall, is recommended (Harkness et al. 1976, p. 46).

As a disabled or elderly person is apt to use anything available for support, all supporting members, such as grab bar, paper holders, soap dishes, towel bars, and bathtub fixtures, must be capable of supporting a minimum of 250 lb. of stress at every point for 5 minutes without permanent deflection (Harkness et al. 1976, p. 47).

Artificial Lighting

Lighting, natural or artificial, is often a secondary cause of accidents. Abrupt changes in lighting levels, glare, and insufficient illumination can cause confusion and accentuate safety hazards. Safety and convenience can be served by artificial lights, controlled by convenient switches, which enable lighting the pathway before entry, and the provision of optimal amount of light for the various visual tasks. Visual acuity increases with illumination. Therefore, wherever good detail vision is needed, illumination levels and contrast ratios must be high. But the bathroom with its inevitable shiny surfaces needs gentle, general light to soften hard edges.

To minimize misguided smears of make-up and slips of the razor, the light source around the bathroom mirror should be functional rather than atmospheric. Efficient mirror lighting for shaving or making up should illuminate the front and the sides of the face. The light should shine onto the user's face, and not into the mirror.

Martyniuk et al. (1973) studied the effect of artificial lighting on impression and behavior. According to their report, using a combination of several different lighting arrangements such as overhead downlight, peripheral wall-lighting, and overhead diffused lighting, makes a space look larger, more pleasant, more friendly, and more satisfying than using a single light does. A combination of incandescent and fluorescent light sources are recommended to yield the most pleasing results.

Ultraviolet light is reported to be efficient in destroying all types of viruses and vegetative bacteria: that is, UVR achieves adequate air disinfection within a given enclosed space. Accordingly, installation of an ultraviolet light for control of respiratory contagion can be considered in bathrooms where great possibilities of epidemic transmission exist, such as those in the shelters for the homeless and in other public areas.

Electricity

The best means of preventing electric shocks is to make electrical outlets not readily accessible from plumbing outlets. For example, electrical light switches and outlets should be placed a minimum of 72 inches away from shower stalls. Electrical equipment such as space heaters and fans should be permanently installed and controlled by a switch.

Installation of GFCIs in circuits servicing bathrooms offers the maximum protection available at present. Conventional electrical protection provided by circuit breakers and fuses guard only against excessively high fault currents.

Color/Pattern

It is generally accepted that color has a direct physiological influence on people as well as a psychological influence related to health and safety. Many variables affect color: surface, texture, lighting, and surrounding colors. Light colors with a light value and bright intensity reflect the light and make surfaces appear larger and farther apart, and as a result make a small room seem larger. It is generally accepted that monochromatic schemes convey a mood of restfulness and serenity.

The eye becomes most sensitive to wavelengths around 500 nm (blue-green). One practical application of this effect is that, to increase the possibility of detection at night, targets or leading lines or patterns on the floor can be made blue-green.

From the standpoint of sanitation, floor materials should have colors and patterns that show up dirt rather than hide it. Endless horizontal or vertical patterns create visual disorientation or confusion and subsequently cause accidents. Certain large or complex patterns can make a small bathroom seem smaller.

Wall/Partition

Rooms with cold exterior walls that collect moisture, or so-called condensation, are not only uncomfortable, but also hygienically undesirable. The risk of condensation in the material of a wall is especially serious in bathrooms in which there is a high concentration of water vapor. In such rooms, it is important to provide a damp-proof layer beneath the surface to prevent the penetration of moisture.

Walls in areas such as bathrooms are easily soiled. Easily cleanable textures and finishes of walls and partitions are thus essential in terms of health. Rough-textured walls are more susceptible to retaining particles than are smooth-textured walls.

Walls are related to the efficiency of ventilation and deposition of particles. Because resistance to air movement is usually proportional to the number of changes in direction the air must make, and as changes in direction may result in deposition of particles, wall arrangements should be carefully determined in terms of airflow.

Problems of Special Groups

The foregoing problems are even greater for special groups such as young children, the aged, and the disabled. But because of the complexity of this issue, and the voluminous body of literature devoted to it, the present paper does not elaborate on specific information related to special groups. Only a few representative examples of these aspects of the subject are included to illustrate their fit into the system.

Summary

In summary, this section has reviewed the literature related to health and safety in general. It has identified seven categories of possible threats and summarized relevant literature. Information applicable to bathroom design, primarily that dealing with residential applications, has been broken down in terms of individual components, and examples of the safety and health implications of each component have been discussed. Many designers are familiar with safety threats, but because threats to health are usually invisible and intangible, they are easily overlooked. To create a truly safe environment, threats to both safety and health should be eliminated. As noted in the introduction, most safety literature is, at present, rather fragmented, varied in format and generally difficult to understand and use. To create safe bathrooms and other environments, designers will have to adopt new tools for organizing and accessing relevant information in a timely manner.

CHAPTER III. METHODOLOGY

Overview

Any successful information management tool must provide clear, understandable and convenient retrieval. This chapter reviews the concept of morphological information organization and computer applications in design information management. It will describe a combination of morphological thinking and computer use to manage information on threats imposed by the physical components of residential bathrooms.

Computerized Information Retrieval

Morphological Analysis

Designers need some means of organizing the limited body of information on health and safety, so as to direct focus to existing concepts and future research needs. One such method is "architectural morphology" or "configurational studies" that has been emerging since the mid-'70s. Morphology, which can be defined as the study of form and spatial structure, alludes to Goethe's original notion of a general *science of possible forms*, covering not just forms in nature, but forms in art, and especially forms of architecture (Steadman, 1983). A basic morphological principle is that all forms are built of subparts and can be recombined to create new forms. Therefore, morphological activity has three primary functions: dissecting forms, defining subparts, and combining subparts.

The design world is actually full of applications of morphologies (Brolander, 1985). Because environmental design is a combination of two-dimensional and three-dimensional components, each component can be analyzed individually and subsequently combined to create a new environment. Morphological analysis can be used to clarify the relations between form and performance. As such, it is an ideal example of the kind of conceptual model needed to give order to design health and safety issues.

Computer Applications

Nowadays, the computer is considered an integral part of the design world. Many environmental designers use it for a host of information-keeping, drafting, and management functions. Their ability to maximize lateral thinking in generating alternative ideas has become essential to design process. These factors, coupled with their capability to access text data quickly via multiple key words, have made the computer a natural technological companion to the morphological approach.

Data storage and retrieval has been simplified by using a computerized data management system. Fortunately, computers, especially personal computers, are becoming more affordable, more powerful, and thus more practical. Modern database programs permit designers to store, retrieve, and sort information, and even to perform mathematical transformation on it.

A Morphological Data-Base of Health and Safety Information on the Macintosh Computer

For the purposes of this study, it is not feasible to discuss databases in great detail. But suffice it to say that one of the greatest merits of database programs is their ability to expand, accommodate and manipulate a great many variables. Morphological activity is based on dissecting and defining subparts; a built environment can be subdivided into basic design components, which can then be analyzed and refined individually. A computer database is one of a few available methods of organizing such an effort.

With this in mind, several steps were undertaken to accomplish the specific purposes of this study:

1. Establishment of a framework into which gathered information could be organized under the categories of design components and threats.
2. Condensation and organization of gathered information into a form that could be easily expressed in a morphological arrangement.
3. Development of illustrations describing each information entry.
4. Refinement of illustration entries into a uniform morphological data-base.

All the above steps were carried out using computers. In specific, the author used a Macintosh personal computer system to store and sort the information gathered and to draw morphological presentations. Two software programs developed for Macintosh computers were used for the morphological presentations: FileMaker™ Plus was the primary software used for the purpose of database management. Super Paint (version 2.0 a) was used to develop graphical illustrations. Text information recorded as separate data units was entered directly into the FileMaker program. Illustrative information was first drawn in Super Paint along with some integral text and then copied into the FileMaker program This was done for both the overall layout of the data "forms" used throughout and for the detailed illustrations unique to each data unit.

Both software packages provided a great deal of flexibility for their intended purposes. Readers should review manufacturers' manuals and aftermarket guides (Sosinsky,1990) for more detailed information on their uses.

The results of the above mentioned process are described in the next chapter.

CHAPTER IV. MORPHOLOGICAL ARRANGEMENT

Data Forms

The result of this study is a computer database that uses a specific form and protocol for summarizing complex safety and health problems in an easily understandable and usable computer format.

The form provides blanks for condensed information by type of design component and type of threat (see Figure 2), problem present, solution, concept proposed, literature source, and a graphic summary. In general, the database provides greatly improved access to relevant safety and health information for practical designers.

In this study, the basic blocks of the database are called "data units". Each data unit has six major sections: design component(s), threat(s), problems, notes, sources, and illustrations. Because the data units are solution-oriented, a data unit having an illustrated solution can have more than one design component, threat, problem, or source. In case there is more than one solution to a problem, each solution is illustrated individually. But, each is also intended to be only an example of a much broader range of solution options.

For easy understanding, a number of symbols are used in the illustrations. For example, in many cases, two opposing examples are drawn and marked with a positive symbol (check in a circle) and a negative one ("X" sign). The meanings of those typical symbols are presented in Figure 3.

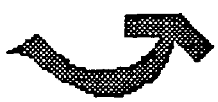
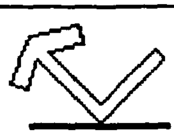
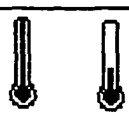
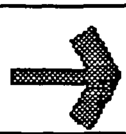
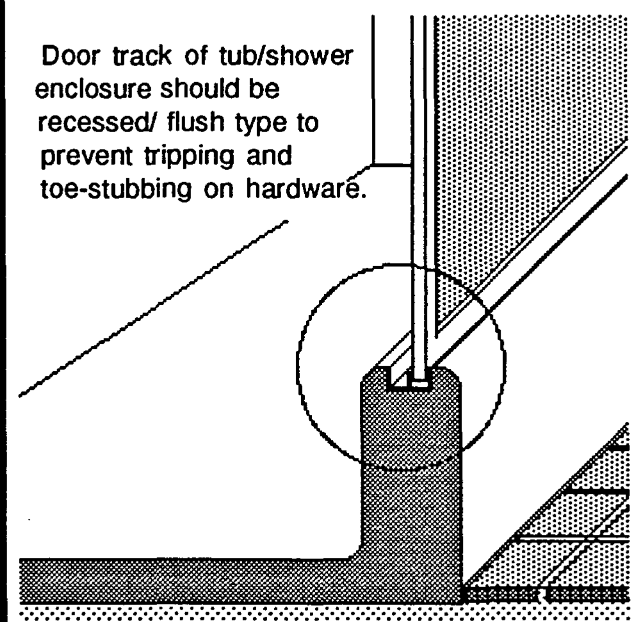
SYMBOL	MEANING	EXPLANATION
	Correct solution	This symbol is a combination of the positive symbol in Western society (check) and that in Oriental society (circle). (see illustrations #6, 11, 14, 15, 18, etc.)
	Incorrect solution	Widely accepted cross-cultural symbol of a negative option. (see illustrations # 6, 11, 14, 15, 18, etc.)
	Organic contaminants	This symbol originally stands for etiological agents.But, in this study, it is also used as a symbol of organic contaminants. (see illustration # 24)
	Air-flow direction	(see illustrations # 47-52)
	Noise	This symbol shows sound reverberation. (see illustrations #34, 89, 98)
	Impact	(see illustrations # 5, 34)
	Water and/or moisture	(see illustrations # 23, 31)
	Resistance	For example, if this symbol is used with the water/moisture symbol, it stands for water resistant character. (see illustrations # 23, 31)
	Heat radiation	(see illustrations # 79, 82)
	Temperature	This symbolizes thermometers, showing a hot temperature and a cool temperature. (see illustration # 33)
	Moving direction	(see illustrations # 30, 37, 86)

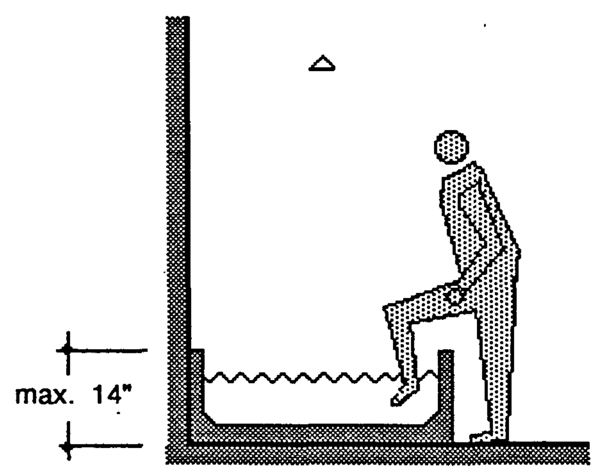
Figure 3. List of symbols

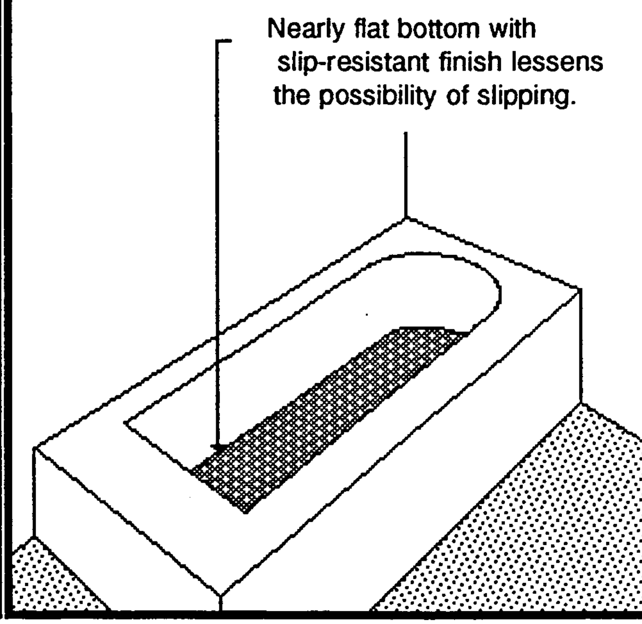
Data Units

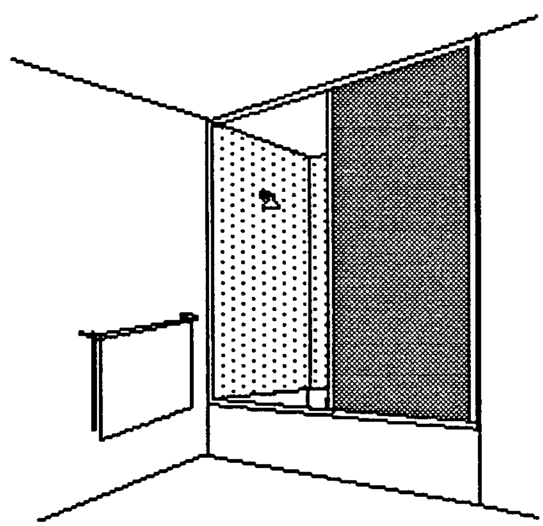
DESIGN COMPONENTS	THREATS TO SAFETY 1. Mechanical	2. Thermal	3. Electrical	THREATS TO HEALTH 4. Chemical	5. Emotional	6. Organic	7. Physiological	
A. Bathtub/Shower	***** **	****			**		****	(17)
B. Floor	***** **				*	**		(10)
C. Circulation/ Accessibility	***	**						(5)
D. Lavatory	***	**				*	*	(7)
E. Toilet/Bidet	***				**	*	**	(8)
F. Window	****				**	**	****	(12)
G. Ventilation				****		*****		(9)
H. Door	***** ***	**			*		*	(12)
I. Grab bar/Handrail	***** ****						*	(10)
J. Natural Lighting	*							(1)
K. Artificial Lighting	***** *	*	*	*	****			(13)
L. Electricity			****					(4)
M. Color/Pattern	*					*		(2)
N. Wall/Partition	***				***	****	*	(11)
O. Other	***			**	*	*	*	(8)
	(58)	(11)	(5)	(7)	.(16)	(17)	(15)	

Figure 4. Distribution Chart of Data Units

Recessed/flush type door tracks to prevent tripping/toe-stubbing.	1
DESIGN COMPONENT(S)	**ILLUSTRATION**
Bathtub/ Shower	
THREAT(S)	
Mechanical	
PROBLEM(S)	
Open grooved door track of tub/shower enclosure poses tripping and toe-stubbing hazards.	
NOTE	
The door track of tub/shower stall should be a recessed/flush type.	
SOURCE(S)	
BOSTI, 1978.	

Bathtubs low enough in height to step over.	2
DESIGN COMPONENT(S)	**ILLUSTRATION**
Bathtub/Shower	
THREAT(S)	
Mechanical	
PROBLEM(S)	
High bathtubs cause accidents while people step in bathtub over the side of tub.	
NOTE	
A standard 14 inch high bathtub permits a person to step in safely over the tub.	
SOURCE(S)	
Thygerson,1977.	

Bathtubs with flat bottoms to prevent slipping.	3
DESIGN COMPONENT(S)	**ILLUSTRATION**
Bathtub/Shower	
THREAT(S)	
Mechanical	
PROBLEM(S)	
Most of slipping accidents occur when an individual uses slippery bathtubs/shower stalls.	
NOTE	
Bathtub and shower stall units should have a nearly flat bottom with an integral slip-resistant finish.	
SOURCE(S)	
Kira, 1976.	

Towel bars within safe reach from tubs/showers.	4
DESIGN COMPONENT(S)	**ILLUSTRATION**
Bathtub/Shower	
THREAT(S)	
Mechanical	
PROBLEM(S)	
Unstable posture while reaching out for towels causes slipping accidents.	
NOTE	
A towel bar or ring should be installed within a convenient reach (max. 6") from the entrance of bathtub/shower.	
SOURCE(S)	
Knox, 1983; Teledyne Brown	

Fiberglass bathtubs/showers to reduce impact. 5

DESIGN COMPONENT(S)

Bathtub/Shower

THREAT(S)

Mechanical

PROBLEM(S)

While using tub/shower stalls, people slip and fall, resulting in being injured by hitting their body parts against tub/shower stalls.

NOTE

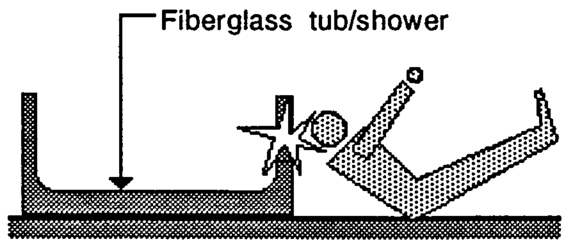
The inherent resilient character of fiberglass can lessen the severity of accidents in tub/shower.

SOURCE(S)

Teledyne Brown Engineering, 1972.

ILLUSTRATION

The inherent character of fiberglass absorbs impact, and reduces the severity of accidents.



Bathtubs without leading steps to prevent falls. 6

DESIGN COMPONENT(S)

Bathtub/Shower

THREAT(S)

Mechanical

PROBLEM(S)

Tubs installed with steps leading up to the edges are extremely hazardous when people enter or leave the tubs.

NOTE

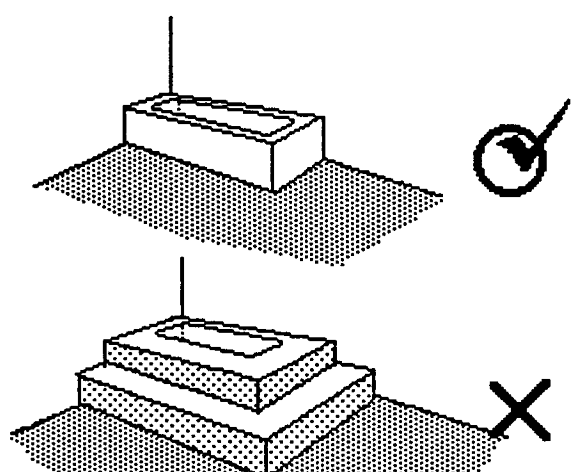
If steps are unavoidable, handrails or grab-bars should be provided to reduce the possibility of accidents.

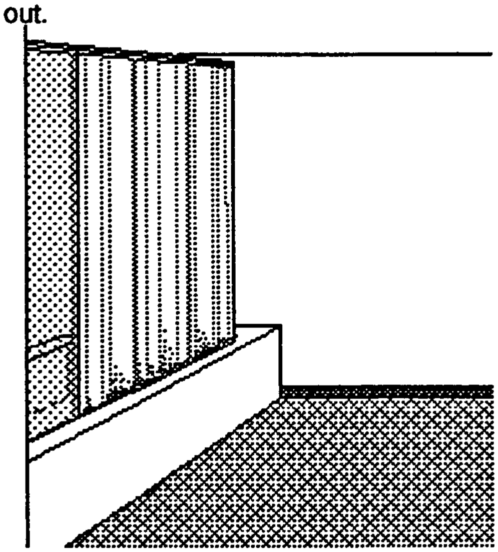
SOURCE(S)

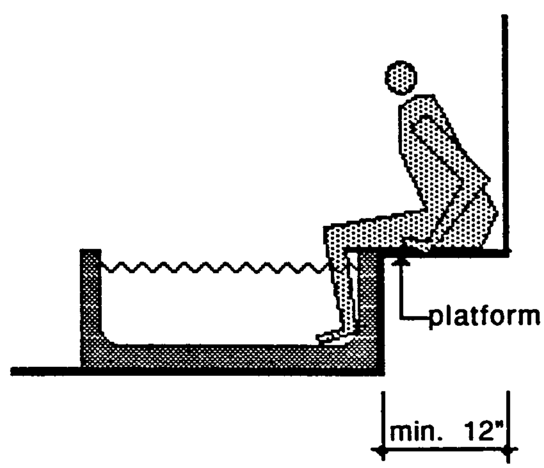
Davidsen, 1989.

ILLUSTRATION

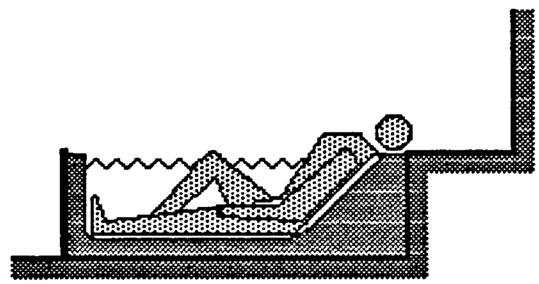
From the viewpoint of safety, steps leading up to the bathtub should be avoided.



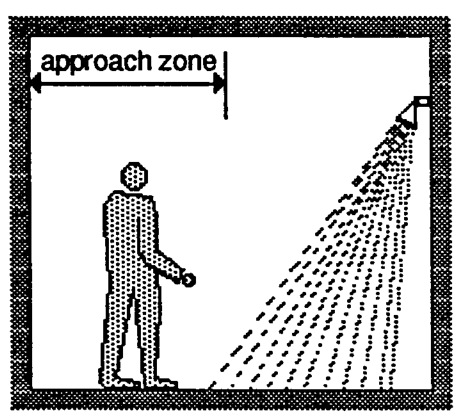
Shower curtains placed inside the tubs to prevent wet floor.	7
DESIGN COMPONENT(S)	**ILLUSTRATION**
Bathtub/Shower	To prevent a wet floor, shower curtain should be placed inside the tub so that water will not be splashed out. 
THREAT(S)	
Mechanical	
PROBLEM(S)	
Wet floors are very dangerous when people step out from the bathtub/shower.	
NOTE	
Correct placement of the rod or hanger will encourage users to keep curtain inside the tub.	
SOURCE(S)	
Teledyne Brown Engineering, 1972.	

Tubs with platforms to provide a safe sitting surfaces.	8
DESIGN COMPONENT(S)	**ILLUSTRATION**
Bathtub/Shower	Platform provides a safe sitting surface when bathers cleanse their bodies, or take a rest. 
THREAT(S)	
Physiological	
PROBLEM(S)	
Skeletal-muscular and cardio-pulmonary stress while taking a bath.	
NOTE	
A platform located at the head of the tub is recommended for both ablebodied and disabled people.	
SOURCE(S)	
Harkness, 1976.	

Bathtubs with good back slope to release back stress.	9
DESIGN COMPONENT(S) Bathtub/Shower **THREAT(S)** Physiological **PROBLEM(S)** Badly designed tubs give skeletal-muscular stress to the bather. **NOTE** The bathtub should have a good slope based on ergonomics to support the back of the bather. The most comfortable angle is in the range from 25 to 40 degrees. **SOURCE(S)** Kira, 1976; Conran, 1978; Malven,	**ILLUSTRATION** Good back slope of the tub based on ergonomics releases skeletal-muscular stress of the bather.



Large enough shower trays to avoid hot streams.	1 0
DESIGN COMPONENT(S) Bathtub/Shower **THREAT(S)** Thermal **PROBLEM(S)** Sudden rush of hot water causes severe burn accidents. **NOTE** The shower tray should be large enough to enable the bather to move out of the hot water stream. **SOURCE(S)** Conran, 1978; Paleno, 1979.	**ILLUSTRATION** To prevent hot water burns, the shower tray should be large enough to enable the bather to move out of the hot water stream.



Shower controls placed not to be under the water sources. | **1 1**

DESIGN COMPONENT(S)

Bathtub/Shower

THREAT(S)

Thermal

PROBLEM(S)

While people adjust water temperature, sudden rush of hot water from shower head causes hot water burns.

NOTE

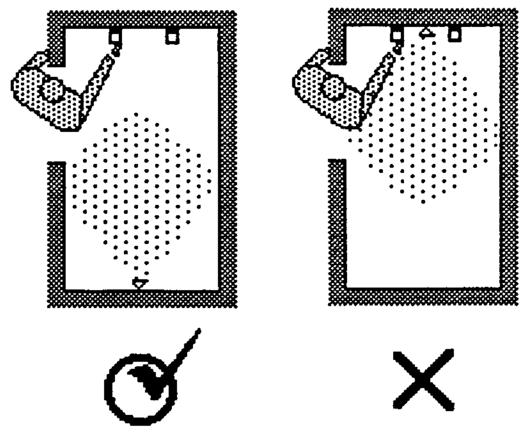
Shower controls should not be positioned under the water source, but accessible from outside the tray.

SOURCE(S)

Conran,1978; Kira, 1976.

ILLUSTRATION

To prevent hot water burns, the shower controls should not be placed under the water source.



Water pipes large enough to provide adequate pressure. | **1 2**

DESIGN COMPONENT(S)

Bathtub/Shower; Lavatory

THREAT(S)

Thermal

PROBLEM(S)

Too narrow shower pipe can cause a sudden rush of hot water when cold water is turned on elsewhere in the house.

NOTE

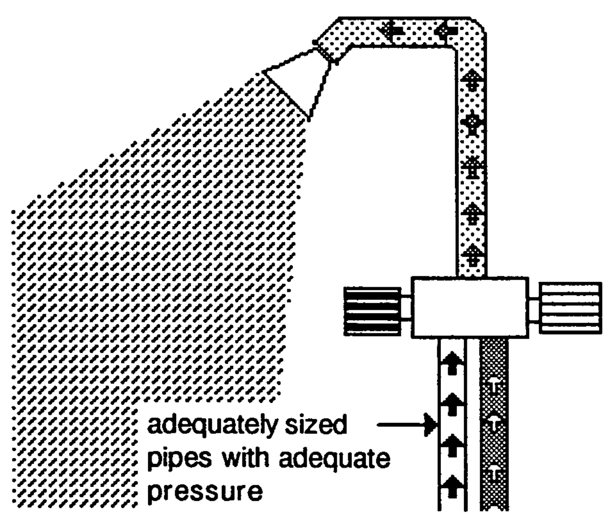
Water supply pipes, especially cold water, should be wide enough to provide adequate pressure at any time.

SOURCE(S)

Godish,1989; Miller,1976;

ILLUSTRATION

To prevent sudden rush of hot water, water supply pipes, especially cold water pipes, should be wide enough with adequate pressure .



Water controls fixed so as not to exceed 115°F. 13

DESIGN COMPONENT(S)

Bathtub/Shower; Lavatory

THREAT(S)

Thermal

PROBLEM(S)

Hot water burn accidents are a common problem in the shower.

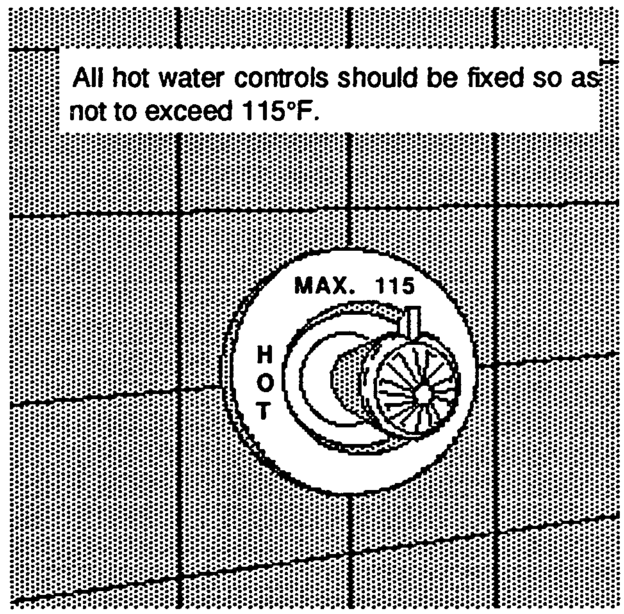
NOTE

This is the more conservative of figures cited--other sources were found that recommended a maximum as high as 120°F.

SOURCE(S)

Knox, 1983; Teledyne Brown

ILLUSTRATION



Bathtubs not placed under openable windows to avoid direct draft. 14

DESIGN COMPONENT(S)

Bathtub/Shower; Window

THREAT(S)

Physiological

PROBLEM(S)

The bather can be exposed to the cold draft directly from windows.

NOTE

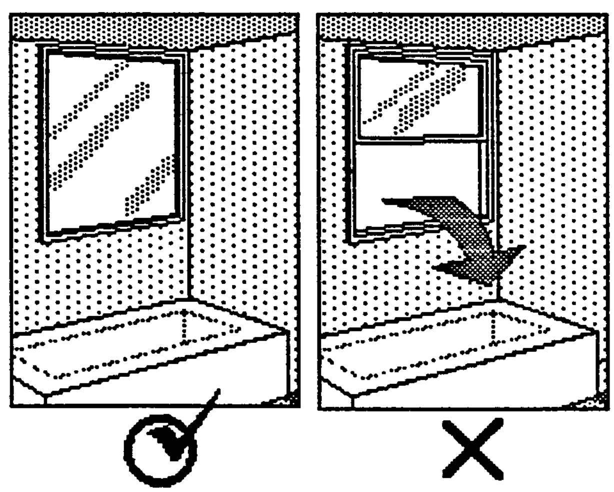
Even when this guideline is followed, the direction of prevailing breezes should be considered when placing tubs and showers relative to windows.

SOURCE(S)

Conran, 1978; Kira, 1976.

ILLUSTRATION

Bathtubs should not be placed under operable windows, because cold draft from those windows annoys bathers.



Bathtubs/showers under high sill windows for privacy. | 15

DESIGN COMPONENT(S)

Bathtub/Shower; Window

THREAT(S)

Physiological, Emotional

PROBLEM(S)

The bather can not feel comfortable or safe because of lack of privacy.

NOTE

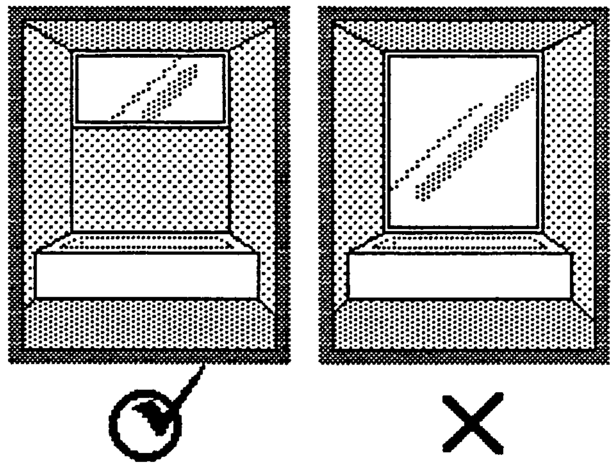
Bathtubs should not be positioned under low-sill windows. If it is inevitable, a blinding device (such as curtain, blinder, etc.) should be installed.

SOURCE(S)

Conran, 1978; Kira, 1976.

ILLUSTRATION

To provide visual privacy, bathtubs should not be positioned under low-sill windows without blinding devices.



Elastic floor materials to absorb impact. | 16

DESIGN COMPONENT(S)

Floor

THREAT(S)

Mechanical

PROBLEM(S)

Hard surfaced floors cause serious injuries when victims fall and hit their heads or other body parts against floor.

NOTE

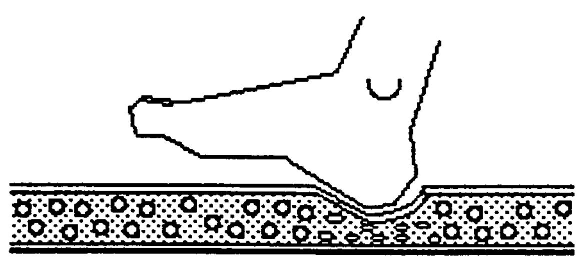
Flooring should be of a material such as carpeting or foam-backed tile that will cushion falls and reduce the severity of injuries.

SOURCE(S)

Erdewijk,1988.

ILLUSTRATION

Elastic floor materials can cushion falls and reduce the severity of injuries.



Ramps replacing single-step level changes to prevent falls.	17

DESIGN COMPONENT(S)

Floor

THREAT(S)

Mechanical

PROBLEM(S)

One step level change on the floor can cause slipping and tripping accidents.

NOTE

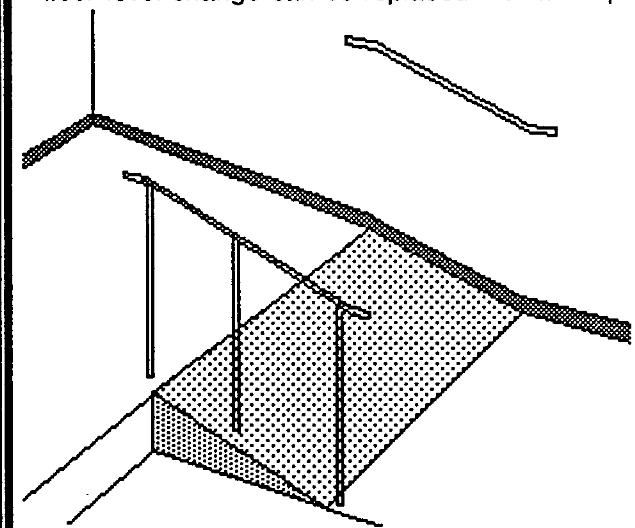
If there is a single-step change in floor level, consider replacing the step with a ramp. Furthermore, the level-change should be well-lighted, with handrails on both side.

SOURCE(S)

Davidsen, 1989.

ILLUSTRATION

To prevent slipping and tripping, single-step floor level change can be replaced with a ramp.



Small rugs with non-skid treatment to prevent skidding.	18

DESIGN COMPONENT(S)

Floor

THREAT(S)

Mechanical

PROBLEM(S)

Victim walking or stepping into bath puts one foot on rug, which slips on shiny floor surface, causing the victim to fall.

NOTE

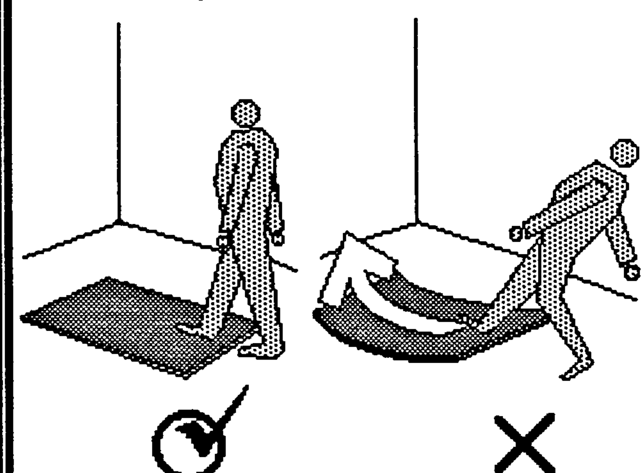
Give a small rug a slip-resistant backing, or apply non-skid strips, foam rubber or an anti-skid spray.

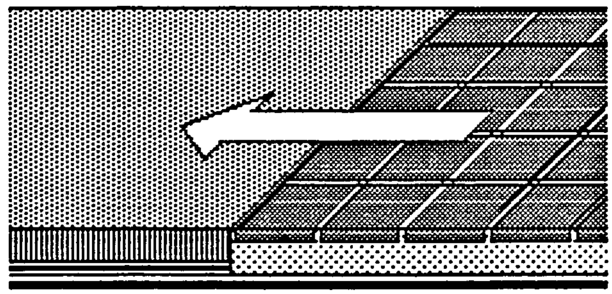
SOURCE(S)

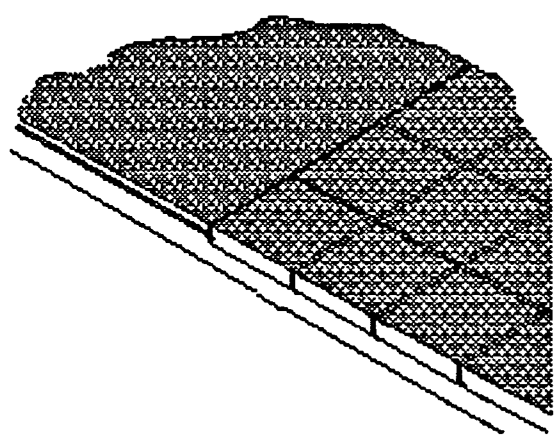
Sinnott,1985; BOSTI, 1978.

ILLUSTRATION

To prevent falls due to skidding small rug, non-skid treatment on the backside of rug is necessary.



Even floor surfaces to prevent tripping.	19
DESIGN COMPONENT(S) Floor **THREAT(S)** Mechanical **PROBLEM(S)** Uneven junction of different kinds of materials causes tripping accidents. **NOTE** The junction should keep even level, and be securely jointed. **SOURCE(S)** BOSTI, 1978.	**ILLUSTRATION** To prevent tripping accidents, materials of different kinds or thicknesses should be elevated to make an even surface. 

Floors without abrupt changes of friction to prevent slipping.	20
DESIGN COMPONENT(S) Floor **THREAT(S)** Mechanical **PROBLEM(S)** Abrupt change in floor surface traction can cause slipping accidents. **NOTE** If different kinds of material are used for the floor, their coefficients of surface friction should be as close as possible. For example, carpet and glossy tile used together can cause slipping accidents. **SOURCE(S)** Rush, 1981; Sinnott, 1985.	**ILLUSTRATION** Different kinds of floor material should not have abrupt change in their surface frictions. 

Rounded nosings at level changes for clear visibility. 21

DESIGN COMPONENT(S)

Floor

THREAT(S)

Mechanical

PROBLEM(S)

Unclearly visible edge of floor level change can cause slipping accidents.

NOTE

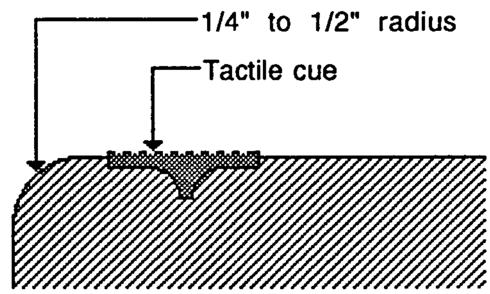
Slightly rounded nosing of floor level change is clearly visible when seen from above. Tactile cue is very helpful in the dark.

SOURCE(S)

Archea,1979; BOSTI, 1978.

ILLUSTRATION

Rounded nosing that is clearly visible, and tactile cue can prevent fall accidents at level change.



Steps with same heights and widths to prevent falls. 22

DESIGN COMPONENT(S)

Floor

THREAT(S)

Mechanical

PROBLEM(S)

Dimensional irregularities of steps in floor cause high accident rates.

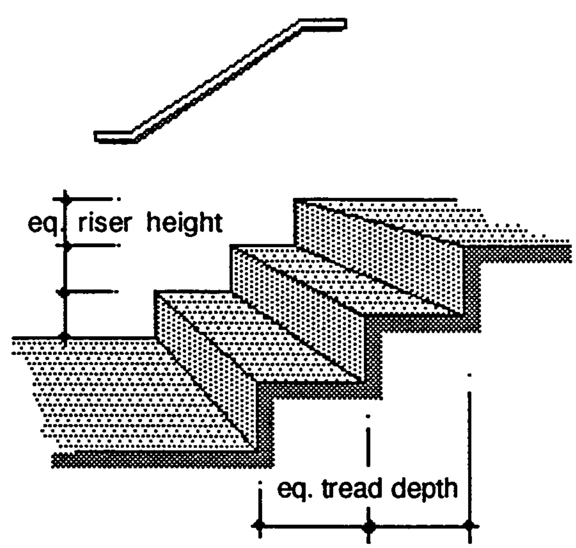
NOTE

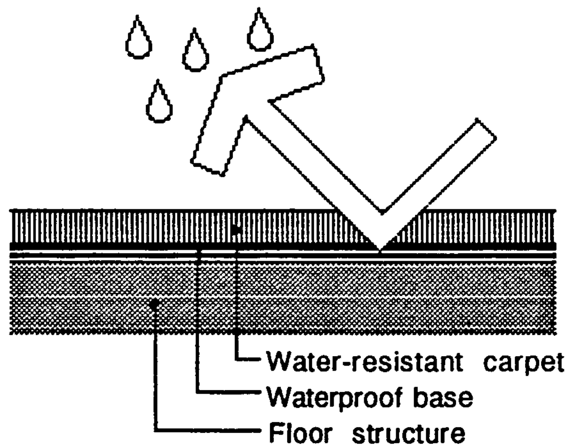
Steps in floor level should have same heights and widths.

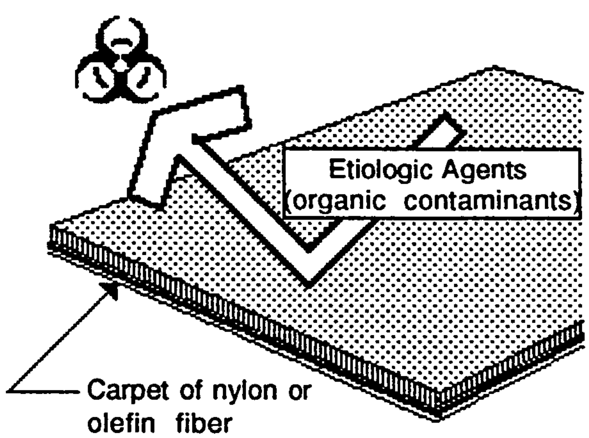
SOURCE(S)

Davidsen,1989; Archea,1979.

ILLUSTRATION



Carpeting with waterproof base to prevent organic growth.	23
DESIGN COMPONENT(S)	**ILLUSTRATION**
Floor	Waterproof base should be installed under the carpet to eliminate wet subfloor condition conducive the growth of organic contaminants. 
THREAT(S)	
Organic	
PROBLEM(S)	
In case of overflow, water permeates into the floor structure, which is hard to dry out.	
NOTE	
Carpeted floor should have a waterproof base to keep the dried condition of floor structure.	
SOURCE(S)	
Conran, 1978.	

Nylon or olefin fibered carpeting to resist soil and moisture.	24
DESIGN COMPONENT(S)	**ILLUSTRATION**
Floor	Soil- and moisture-resistant nature of nylon or olefin fiber prevents organic contamination. 
THREAT(S)	
Organic, Emotional	
PROBLEM(S)	
Soiled carpet is hard to clean out, and provides good environment to organic contaminants.	
NOTE	
Carpets of nylon or olefin fiber are virtually soil and moisture resistant while providing the functional benifits of warmth and noise reduction.	
SOURCE(S)	
Grandjean, 1973; Teledyne Brown	

Enough free space outside tubs for people to dry themselves. | **25**

DESIGN COMPONENT(S)

Circulation/ Accessibility

THREAT(S)

Mechanical

PROBLEM(S)

people hit the glass partition of tub/shower, and are injured while they are drying themselves outside tub/shower.

NOTE

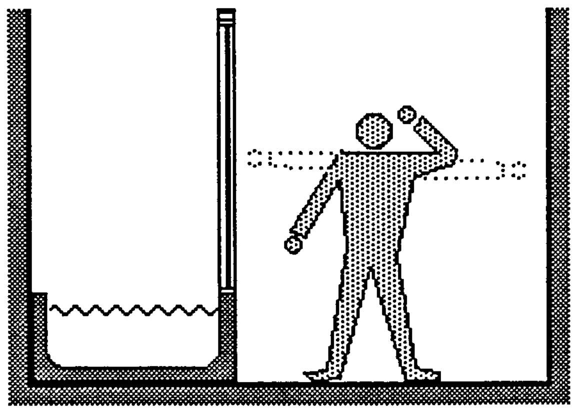
Adequate space should be provided outside the tub/shower area for people to dry themselves off away from the glass of a shower enclosure. (2.5' by 3.5' is the minimum space.)

SOURCE(S)

Paleno, 1979.

ILLUSTRATION

Enough free space for people to dry themselves without striking should be provided outside of tub/shower.



Doors swinging against walls to prevent being struck. | **26**

DESIGN COMPONENT(S)

Circulation/Accessibility

THREAT(S)

Mechanical

PROBLEM(S)

People near the door who is using a bathroom fixture can be struck by the opening or closing door operated by another person.

NOTE

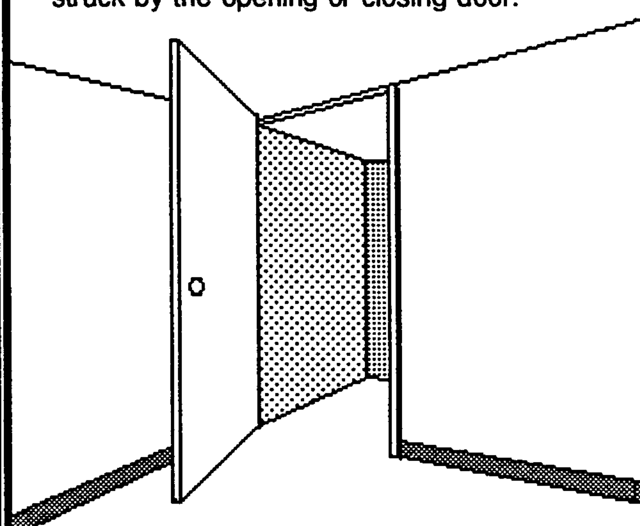
When possible, it is best to swing the door against a wall to eliminate the chance of striking an individual using one of the fixtures.

SOURCE(S)

BOSTI, 1978.

ILLUSTRATION

Swing the door against a wall to prevent being struck by the opening or closing door.



Enough space to pass through.	27

DESIGN COMPONENT(S)

Circulation/Accessibility

THREAT(S)

Mechanical

PROBLEM(S)

People strike an element while passing through a too narrow space.

NOTE

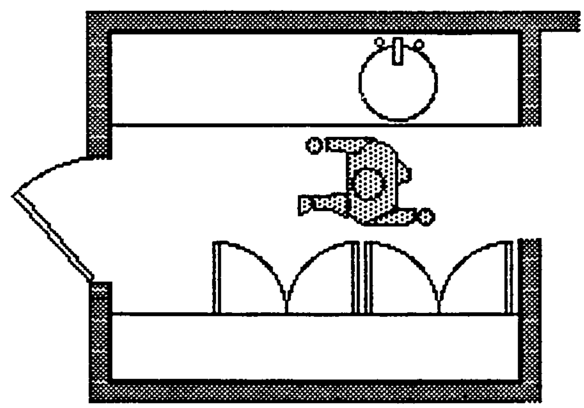
Arrange furniture so that people can pass through bathroom and move through doorways with out squeezing between objects.

SOURCE(S)

Paleno, 1979.

ILLUSTRATION

Ample space for free movement should be provided to avoid the possibility of collision of body members with surrounding fixtures and walls.



Large counter space to place numerous bathroom items.	28

DESIGN COMPONENT(S)

Lavatory

THREAT(S)

Mechanical

PROBLEM(S)

Inadequate counter space for placement of numerous items such as toothbrush, safety razor, soap, etc., causes accidents.

NOTE

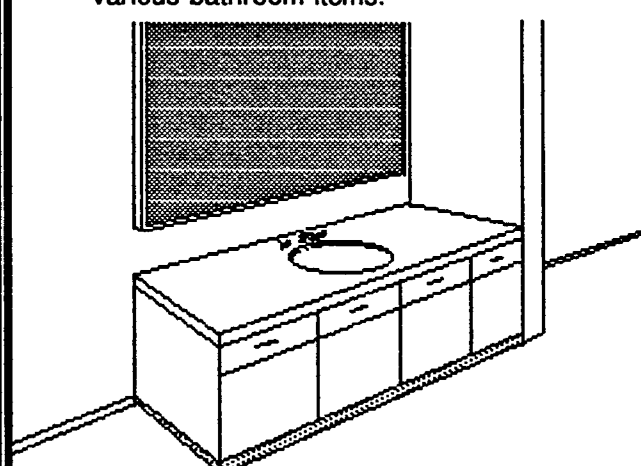
A space at least 3 feet long for each lavatory is required.

SOURCE(S)

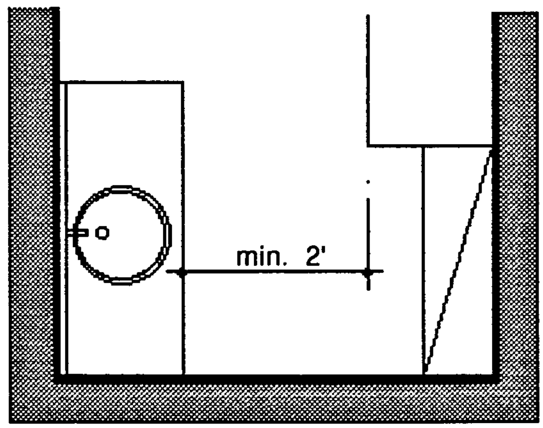
Knox, 1983.

ILLUSTRATION

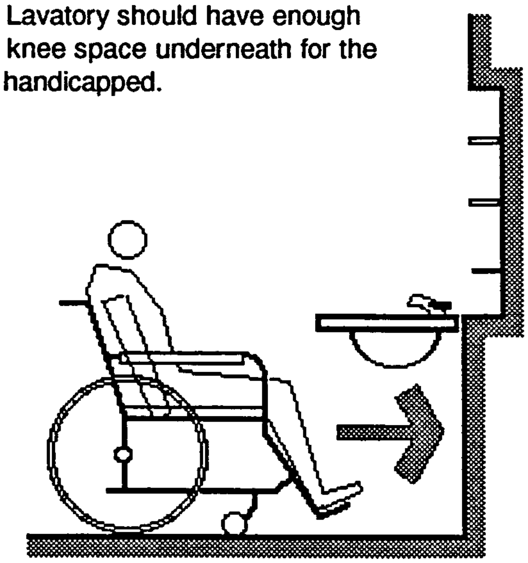
Enough counter space, at least 3 feet long, for each lavatory should be provided for various bathroom items.

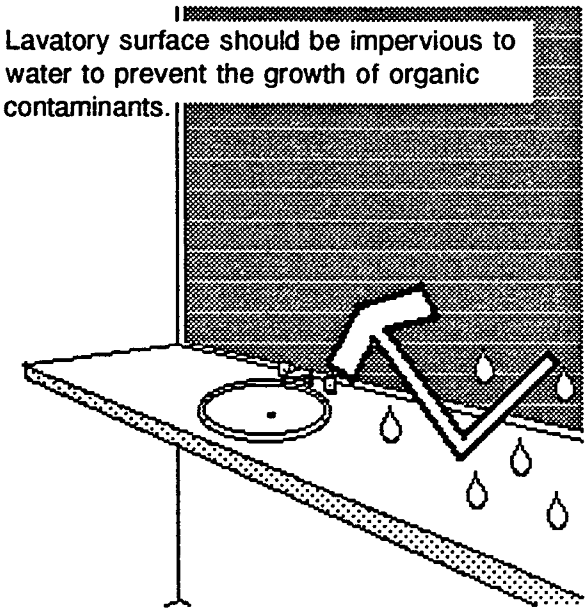


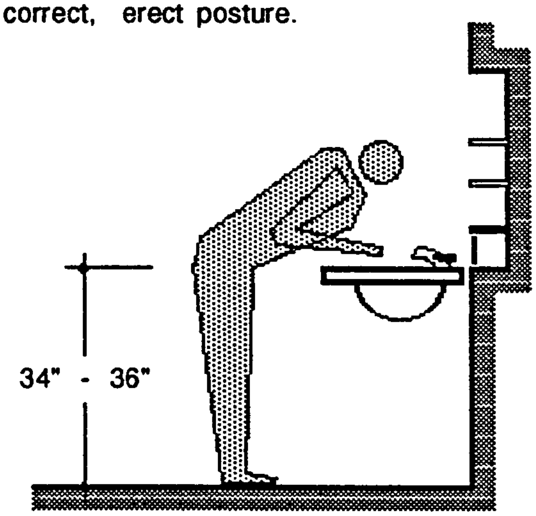
Adequate clearances for comfortable physical movement.	29
DESIGN COMPONENT(S)	**ILLUSTRATION**
Lavatory	Adequate clearance between the back of lavatory and the opposing wall should be provided for comfortable movement and safety.
THREAT(S)	
Mechanical	
PROBLEM(S)	
Inadequate clearance between the back of lavatory and the opposing wall or fixture can cause accidents.	
NOTE	
At least 2 feet deep floor space is required in front of the lavatory.	
SOURCE(S)	
Teledyne Brown Engineering, 1972.	



Enough space underneath lavatories for wheelchair users.	30
DESIGN COMPONENT(S)	**ILLUSTRATION**
Lavatory	Lavatory should have enough knee space underneath for the handicapped.
THREAT(S)	
Mechanical	
PROBLEM(S)	
Inaccessibility of wheelchair users at bathroom fixtures.	
NOTE	
Leg space should also be free of pipes and other impediments.	
SOURCE(S)	
Harkness, 1976; Knox, 1983.	



Impervious lavatory tops to prevent organic growth.	31
DESIGN COMPONENT(S)	**ILLUSTRATION**
Lavatory	Lavatory surface should be impervious to water to prevent the growth of organic contaminants. 
THREAT(S)	
Organic	
PROBLEM(S)	
Organic contamination.	
NOTE	
Lavatory surface should be impervious to water for easy maintainance, and sanitary. Molded integral sink is preferable.	
SOURCE(S)	
BOSTI, 1978.	

Lavatory counters higher than current practice to release stress.	32
DESIGN COMPONENT(S)	**ILLUSTRATION**
Lavatory	34-36 inch lavatory counter height, higher than current practice, encourages ergonomically correct, erect posture. 
THREAT(S)	
Physiological	
PROBLEM(S)	
Current lavatory counter height is too low and causes physiological stress.	
NOTE	
34 to 36 inch counter height, which is higher than current practice, is recommendable for physiological comfort.	
SOURCE(S)	
Conran, 1978.	

Insulated pipes to prevent burns. | 33

DESIGN COMPONENT(S)

Lavatory

THREAT(S)

Thermal

PROBLEM(S)

Handicapped persons in wheelchair who have no sensory perception in the legs easily get burned from the hot water and drain pipes under the lavatory.

NOTE

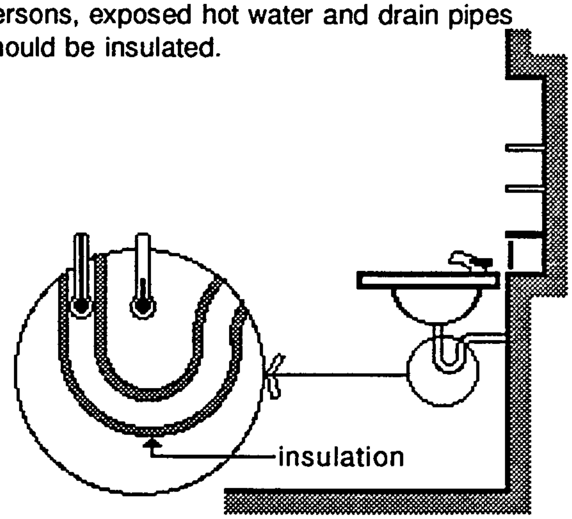
Exposed hot water and drain pipes should be insulated to safeguard disabled persons.

SOURCE(S)

Harkness, 1976; Knox, 1983.

ILLUSTRATION

To prevent burns, especially of handicapped persons, exposed hot water and drain pipes should be insulated.



Sound-absorbant toilet seat materials to prevent clatter. | 34

DESIGN COMPONENT(S)

Toilet/Bidet

THREAT(S)

Emotional

PROBLEM(S)

Emotional embarrassment due to unintentional noise making.

NOTE

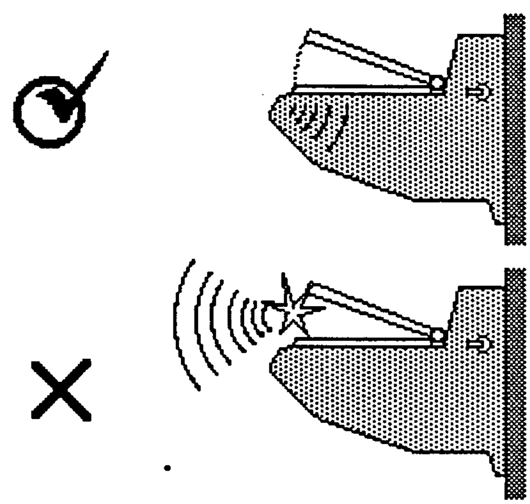
soft toilet seats or carpeted commode lids are desirable to prevent clatter.

SOURCE(S)

Miller,1985; Mazzurco,1986.

ILLUSTRATION

Toilet seats and lids should made of sound-absorbable materials to prevent clatter.



Toilet/bidet units with quiet-flushing and refilling mechanism.	35

DESIGN COMPONENT(S)

Toilet/Bidet

THREAT(S)

Emotional

PROBLEM(S)

Some sounds associated with bathroom use may be a source of considerable embarrassment to the user.

NOTE

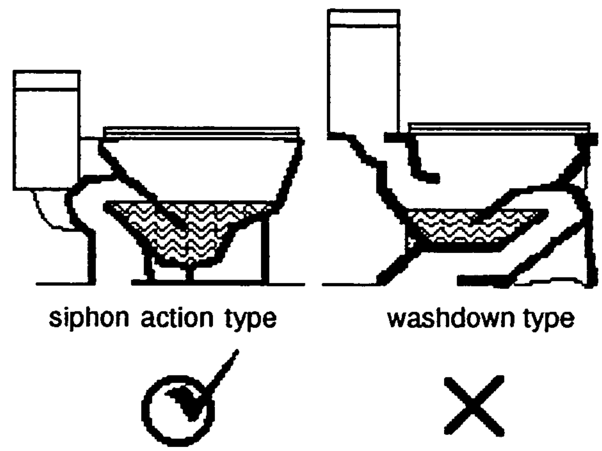
By using more but smaller water streams--moving over smooth surfaces of fixtures rather than pouring directly into a standing pool, siphon-action types of water closets are quieter than wash-down types.

SOURCE(S)

Miller, 1985; Mazzurco, 1986.

ILLUSTRATION

Toilet and bidet units with quiet flushing and refilling cycles are recommended.



Fixture edges rounded to reduce the severity of injuries.	36

DESIGN COMPONENT(S)

Toilet/Bidet

THREAT(S)

Mechanical

PROBLEM(S)

People slip and fall, striking nearby fixtures including toilets and bidets.

NOTE

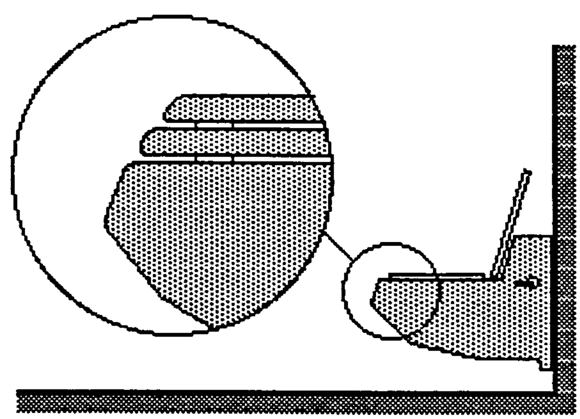
Bathroom fixtures should have rounded edges and the most resilient surfaces available to reduce the severity of injuries.

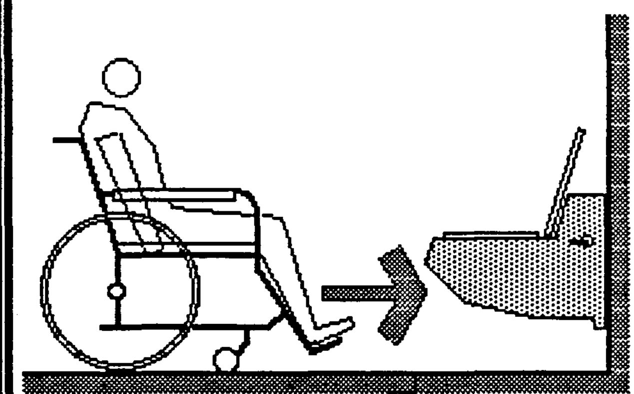
SOURCE(S)

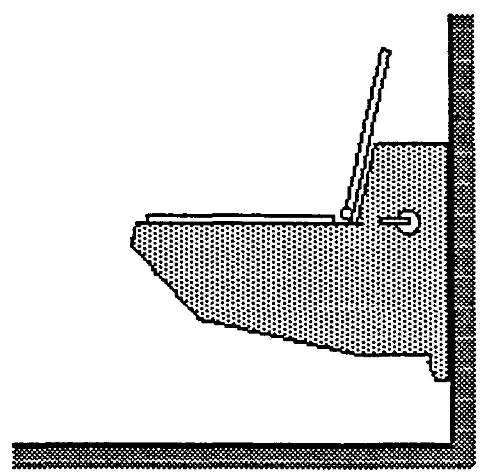
Kira, 1976.

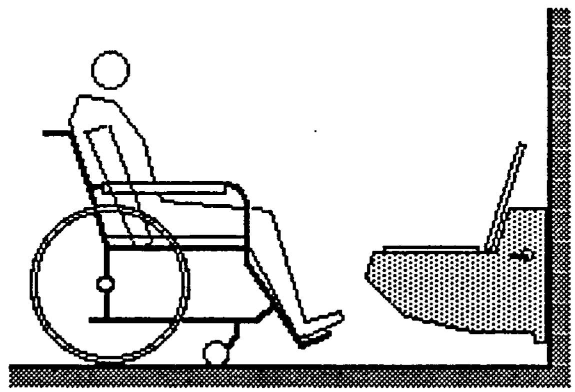
ILLUSTRATION

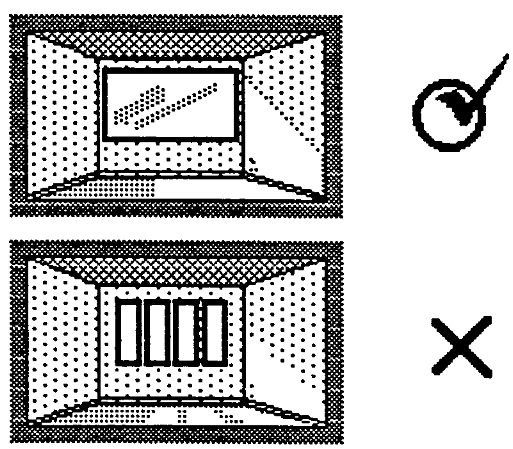
To reduce the severity of injuries resulting from accidential contact with fixtures, bathroom fixtures should have rounded edges and resilient surfaces.

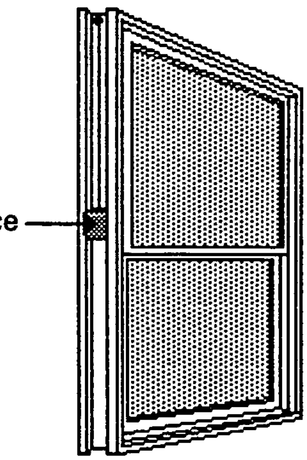


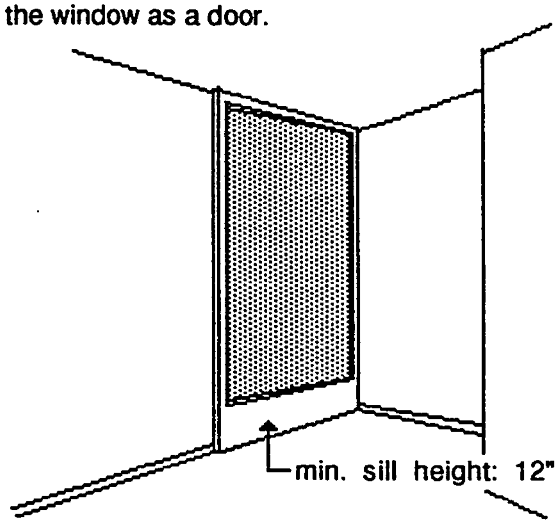
Wall-hung type toilet/bidet units for the handicapped.	37
DESIGN COMPONENT(S)	**ILLUSTRATION**
Toilet/Bidet	Wall-hung type toilet and bidet units allow close positioning of a wheelchair without the footrest hitting the toilet bowl. 
THREAT(S)	
Mechanical, Physiological	
PROBLEM(S)	
Floor models of toilet and bidet do not allow close positioning of a wheelchair without the footrest hitting the toilet bowl.	
NOTE	
Wall-hung toilet and bidet units eliminate the toe stubbing base of floor models. This type is more flexible to change in seat height.	
SOURCE(S)	
Moore, 1974; Harkness, 1976.	

Wall-hung toilet/bidet units for easy cleaning.	38
DESIGN COMPONENT(S)	**ILLUSTRATION**
Toilet/Bidet	Wall-hung type toilet and bidet units allow easy cleaning of the floor and of the units themselves. 
THREAT(S)	
Organic	
PROBLEM(S)	
Some floor models of toilets and bidets make it difficult to clean the floor and units themselves.	
NOTE	
Wall-hung type toilet and bidet units allow of easy floor cleaning.	
SOURCE(S)	
Moore,1974; Kira, 1976.	

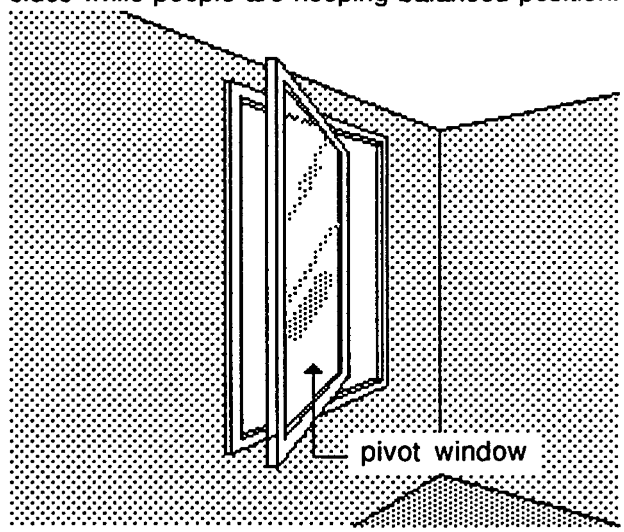
Compromised toilet heights to accomodate the disabled.	39
DESIGN COMPONENT(S)	**ILLUSTRATION**
Toilet/Bidet	18" high toilet/bidet units can be used by both the disabled and the ablebodied, as 16" standard units are too low for the disabled. 
THREAT(S)	
Physiological	
PROBLEM(S)	
Standard toilet height 16" is too low for the disabled.	
NOTE	
compromised height of 18" may be adapted for both the disabled and the ablebodied. The height of wall-hung units is easy to adjust.	
SOURCE(S)	
Harkness,1976; Knox, 1983.	

Continuous windows to provide spacious feeling.	40
DESIGN COMPONENT(S)	**ILLUSTRATION**
Window	In a square-like room, a continuous window, rather than several small windows, on a short wall makes the room seem more spacious. 
THREAT(S)	
Emotional	
PROBLEM(S)	
Bathrooms are often quite small, which can result in extreme, stressful feelings of enclosure.	
NOTE	
A continuous window on a short wall rather than on a long one, gives a more spacious feeling to a square-like room than do several small windows.	
SOURCE(S)	
Collins,1975.	

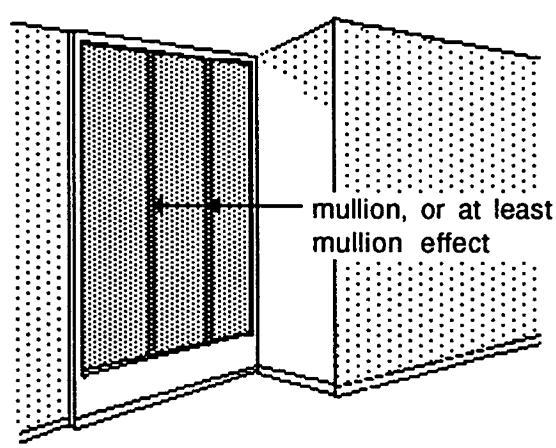
Counter-balanced windows to prevent injury from falling sashes.	41
DESIGN COMPONENT(S)	**ILLUSTRATION**
Window	Counter-balancing mechanism reduces the severity of sash fall accidents, and the starting force to open a stationary window moving. 
THREAT(S)	
Mechanical	
PROBLEM(S)	
People sustain injuries when a window sash falls. Unacceptable force to start a window moving can cause skeletal/ muscular injuries.	
NOTE	
Counter-balancing mechanisms can prevent window sash falls and reduce the force needed to start a stationary window moving.	
SOURCE(S)	
Grandjean, 1973.	

Window walls with high sills to prevent misinterpretation.	42
DESIGN COMPONENT(S)	**ILLUSTRATION**
Window	Window wall should have enough sill height so that accidents don't result from misinterpreting the window as a door. 
THREAT(S)	
Mechanical	
PROBLEM(S)	
Window wall can be misperceived, and people can rush into the window.	
NOTE	
If window walls are planned, minimum sill height of 12" above the floor level should be provided.	
SOURCE(S)	
Teledyne Brown Engineering, 1972.	

Pivot type windows for easier cleaning of both sides.	43
DESIGN COMPONENT(S)	**ILLUSTRATION**
Window	Pivot window type is easily cleanable on both sides while people are keeping balanced position.
THREAT(S)	
Mechanical	
PROBLEM(S)	
Unbalanced position to clean both sides of windows causes accidents.	
NOTE	
All window should be cleanable on both sides while people are standing safely inside. From that viewpoint, pivot window type is desirable.	
SOURCE(S)	
Raschko,1982; Sinnott, 1985.	



Mullion effects on window walls to prevent crashing into openings.	44
DESIGN COMPONENT(S)	**ILLUSTRATION**
Window	Mullion effect can prevent people from crashing into glazed openings.
THREAT(S)	
Mechanical	
PROBLEM(S)	
Window wall can be misperceived, and people can rush into the window.	
NOTE	
Mullion effect can also be achieved by sticking noticible stripes on the window, or applying etched or sand-blasted glass patterns.	
SOURCE(S)	
Rush, 1981.	



Double- or triple-paned windows to prevent condensation.	**45**

DESIGN COMPONENT(S)

Window

THREAT(S)

Organic

PROBLEM(S)

Condensation

NOTE

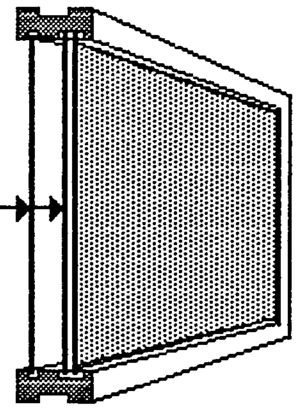
Double or triple-paned windows should be considered to increase thermal resistance of windows.

SOURCE(S)

Godish, 1989.

ILLUSTRATION

To prevent vapor condensation and to increase energy efficiency, double- or triple-paned window is desirable.



For sloped skylights, use drip ledges to drain condensation.	**46**

DESIGN COMPONENT(S)

Window

THREAT(S)

Organic; Physiological

PROBLEM(S)

Cold water dripping from ceilings or skylight annoys bathers, and makes damp environments.

NOTE

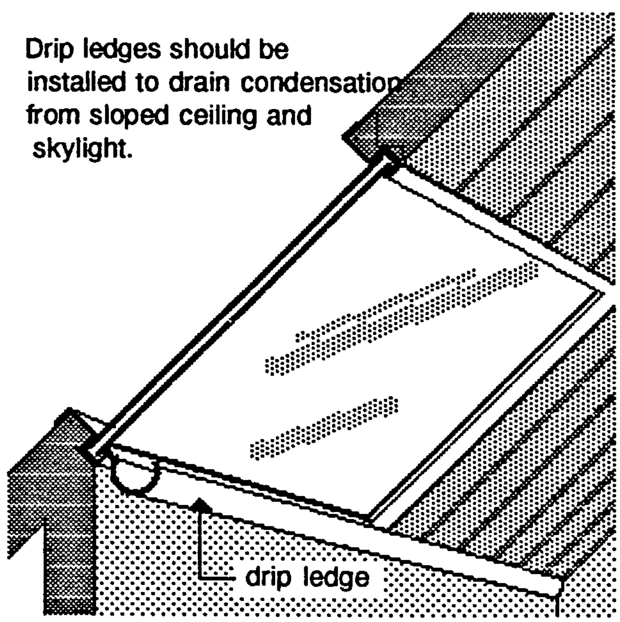
Install drip ledges to drain condensation from sloped ceilings or skylights.

SOURCE(S)

Conran, 1978.

ILLUSTRATION

Drip ledges should be installed to drain condensation from sloped ceiling and skylight.



Easily movable windows to prevent physiological stress.	47

DESIGN COMPONENT(S)

Window

THREAT(S)

Physiological

PROBLEM(S)

Trying to open stuck windows causes skeletal-muscular stress and slipping accidents.

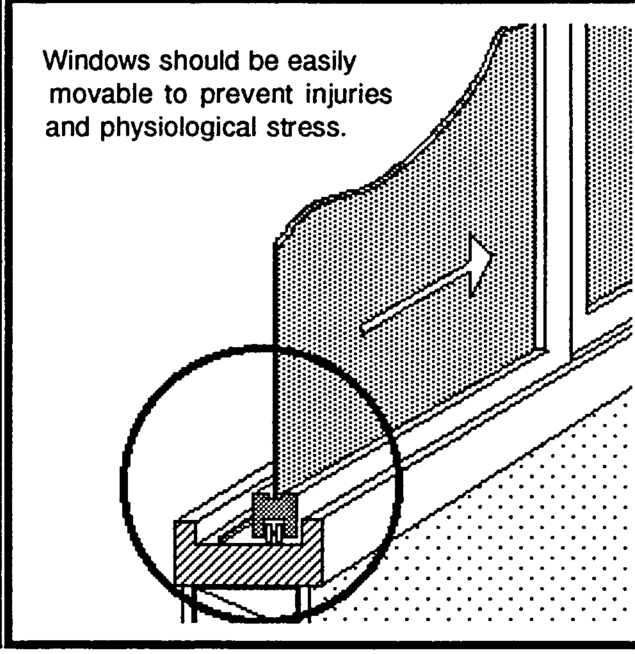
NOTE

Sliding windows on rollers, or casement windows with easily moving controls are prefered. The max. acceptable force to a stationary window is 15 pound.

SOURCE(S)

Raschko, 1982.

ILLUSTRATION



Equally sized inlets and outlets to maximize ventilation efficiency.	48

DESIGN COMPONENT(S)

Ventilation

THREAT(S)

Chemical; Organic

PROBLEM(S)

Ventilation efficiency is closely related to the size of inlet and outlet openings.

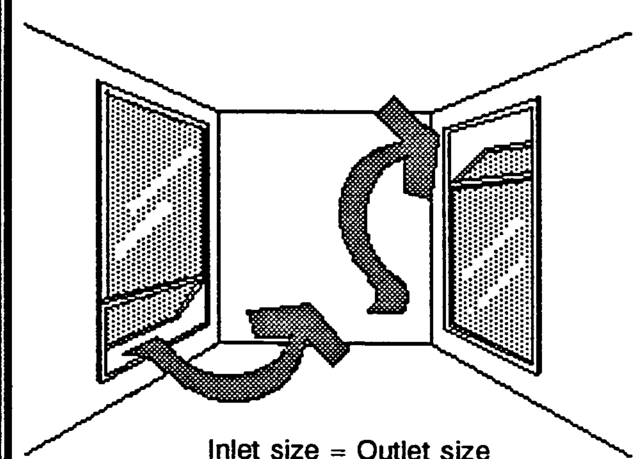
NOTE

To achieve the most efficient natural ventilation, inlet and outlet openings should be of nearly equal area.

SOURCE(S)

Melaragno,1982; Rodahl, 1986.

ILLUSTRATION



Inlets lower than outlets for natural convection ventilation.	49

DESIGN COMPONENT(S)

Ventilation

THREAT(S)

Chemical; Organic

PROBLEM(S)

Ventilation efficiency is closely related to the locations of inlet and outlet openings.

NOTE

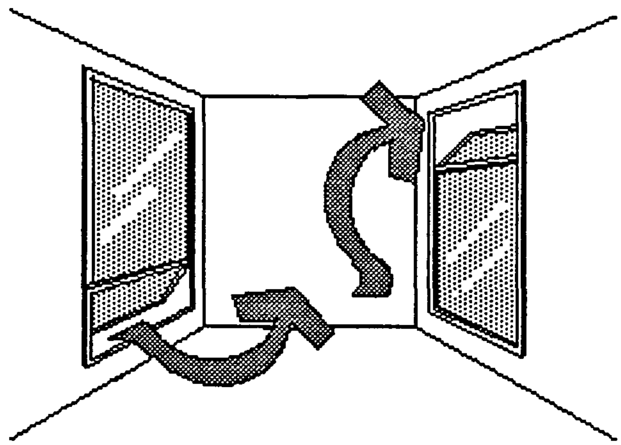
For the most efficient natural ventilation through windows, the inlet should be lower than the outlet.

SOURCE(S)

Melaragno,1982; Rodahl, 1986.

ILLUSTRATION

For efficient natural ventilation, the inlet should be lower than the outlet.



Maximized distances between inlets and outlets for efficiency.	50

DESIGN COMPONENT(S)

Ventilation

THREAT(S)

Chemical, Organic

PROBLEM(S)

The vertical distance between inlet and outlet openings affects ventilation efficiency.

NOTE

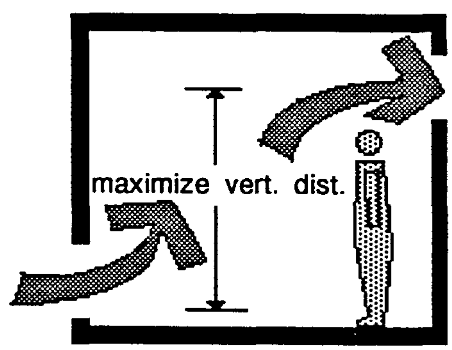
To achieve the most efficient natural ventilation, the vertical distance between inlet and outlet openings should be as great as possible.

SOURCE(S)

Rodahl,1986.

ILLUSTRATION

To achieve the most efficient natural ventilation, the vertical distance between inlet and outlet openings should be as great as possible.



Inlet higher than outlet for efficient mechanical ventilation.	5 1

DESIGN COMPONENT(S)

Ventilation

THREAT(S)

Chemical, Organic

PROBLEM(S)

Ventilation efficiency is closely related to the locations of inlet and outlet openings.

NOTE

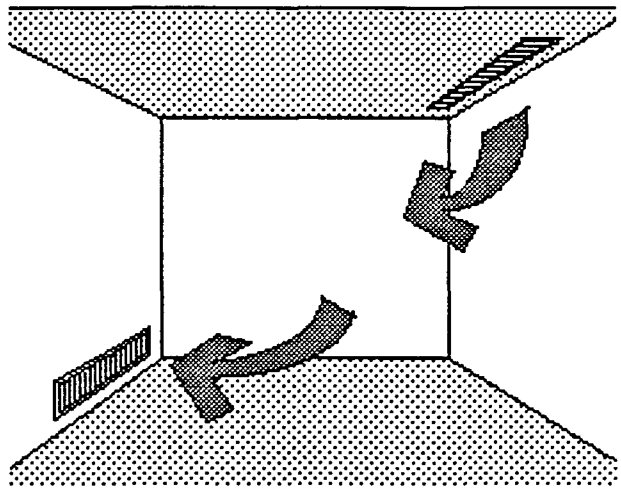
For the most efficient mechanical ventilation, the inlet should be higher than the outlet.

SOURCE(S)

Walter, 1988.

ILLUSTRATION

For efficient mechanical ventilation, the inlet should be higher than the outlet.



Enough air inflow to prevent depressurization.	5 2

DESIGN COMPONENT(S)

Ventilation

THREAT(S)

Organic

PROBLEM(S)

When extractor fans are in use without adequate air-inflow, depressurization of the space can cause to suck decayed air borne

NOTE

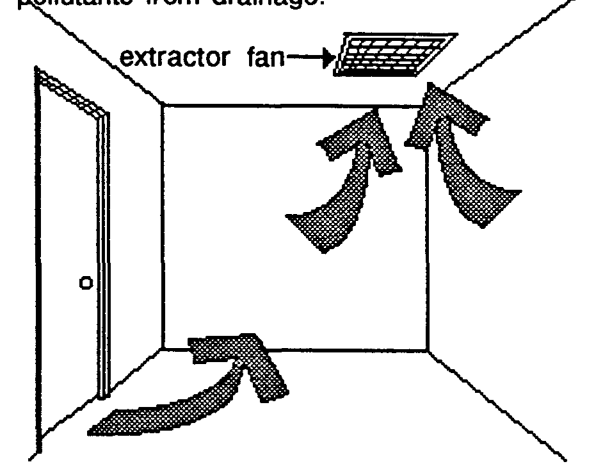
Enough air inflow from the outside should be provided if extractor fans are in use.

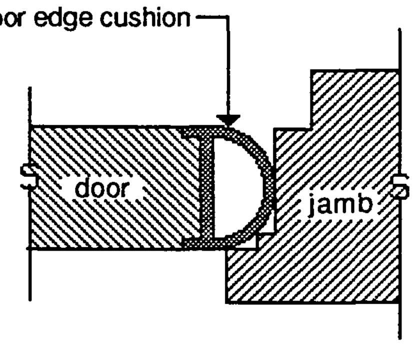
SOURCE(S)

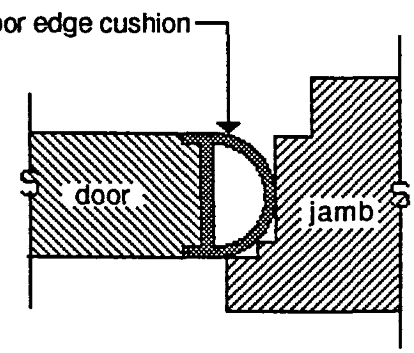
Turiel,1985.

ILLUSTRATION

When a extractor fan is in use, provide enough air inflow from outside to insure that depressurization effect draws decayed airborne pollutants from drainage.



Doors with soft edge cushions to provide acoustic privacy.	5 3
DESIGN COMPONENT(S)	**ILLUSTRATION**
Door	Soft door edge cushions reduce sound transmission and provide acoustic privacy. 
THREAT(S)	
Emotional	
PROBLEM(S)	
People are very sensitive about the noise they make while they use bathroom fixtures, especially water closet.	
NOTE	
Providing soft door edge cushions can reduce sound transmission through doors. Cushions can be made of PVC or ABS.	
SOURCE(S)	
BOSTI, 1978.	

Doors with soft edge cushions to prevent finger accidents.	5 4
DESIGN COMPONENT(S)	**ILLUSTRATION**
Door	Soft door edge cushion eliminates finger accidents, and provides acoustic privacy. 
THREAT(S)	
Mechanical	
PROBLEM(S)	
Finger injuries caught between the door edge and the door jamb.	
NOTE	
Providing soft door edge cushions can eliminate finger accidents. Cushions can be made of PVC or ABS.	
SOURCE(S)	
BOSTI, 1978.	

Out-swinging doors for access/exit in emergencies. 55

DESIGN COMPONENT(S)

Door

THREAT(S)

Mechanical

PROBLEM(S)

In case of emergency, an unconscious body lying next to the door will make entry dificult.

NOTE

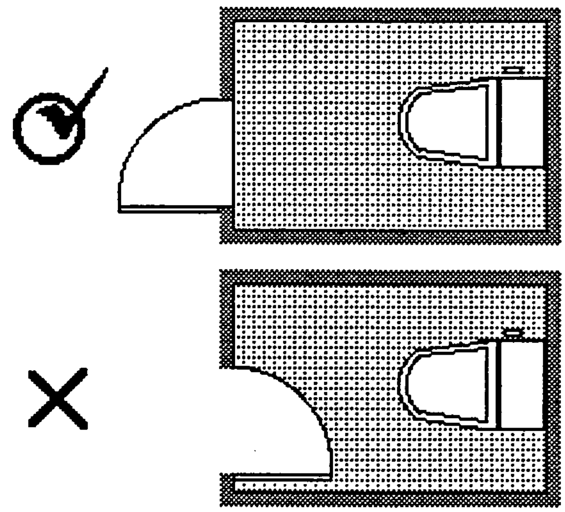
The water closet door should swing outward, and be a minimum of 32 inches wide to accommodate a wheelchair.

SOURCE(S)

Raschko, 1982; Knox, 1983.

ILLUSTRATION

For emergency case, the door to the bathroom and the toilet should swing out.



Doors positioned so as not to conflict with each other. 56

DESIGN COMPONENT(S)

Door

THREAT(S)

Mechanical

PROBLEM(S)

Two conflicting doors cause severe accidents.

NOTE

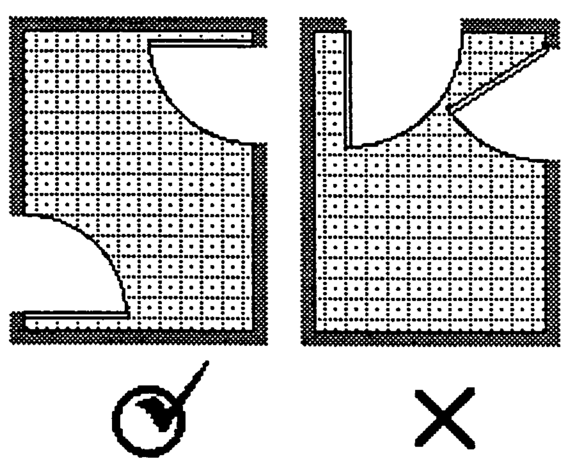
Doors should be positioned so that no two doors will contact each other when either or both are opened.

SOURCE(S)

Sinnott, 1985.

ILLUSTRATION

Doors should not conflict with other doors when either or both are opened.



Doors seperated from wet floor conditions to prevent slipping.	57

DESIGN COMPONENT(S)

Door

THREAT(S)

Mechanical

PROBLEM(S)

Slippery conditions near doors easily cause fall accidents, especially when individuals step into the bathroom from outside.

NOTE

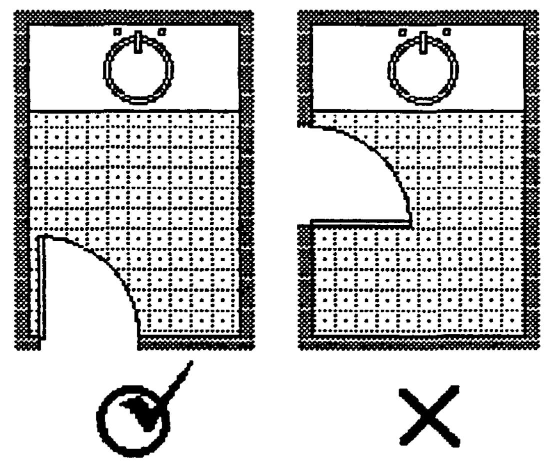
Doors should be positioned as far from lavatories, showers, and tubs.
Door swinging direction should be carefully considered.

SOURCE(S)

English, 1988; Teledyne Brown

ILLUSTRATION

To prevent fall accidents due to slippery floor conditions near doors, doors should be placed as far from lavatories, showers, and tubs as possible.



Friction type latches on shower enclosures for emergency cases.	58

DESIGN COMPONENT(S)

Door

THREAT(S)

Mechanical

PROBLEM(S)

Locking type latches used on bathtub and shower can not be easily opened from outside in an emergency.

NOTE

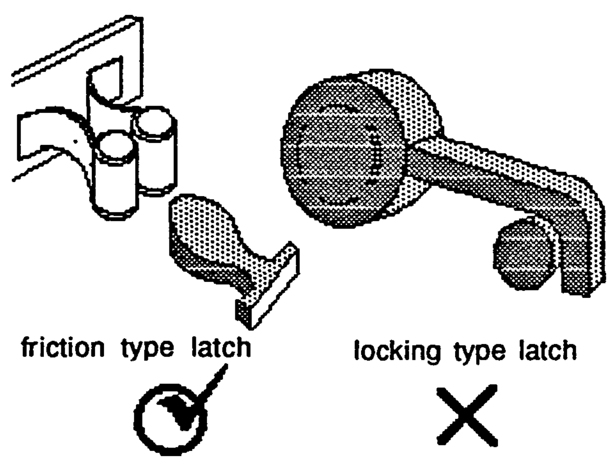
If a latching device is required on bathtub/shower enclosures, a friction type should be used to be easily opened from outside in an emergency case.

SOURCE(S)

Teledyne Brown Engineering, 1972.

ILLUSTRATION

To be easily opened from outside in an emergency, latches on bathtub and shower enclosures should be friction types rather than locking types.



Doors unlockable from outside for emergency cases. | **5 9**

DESIGN COMPONENT(S)

Door

THREAT(S)

Mechanical, Thermal, Physiological

PROBLEM(S)

Doors unopenable from outside can make accidents worse in case of emergency.

NOTE

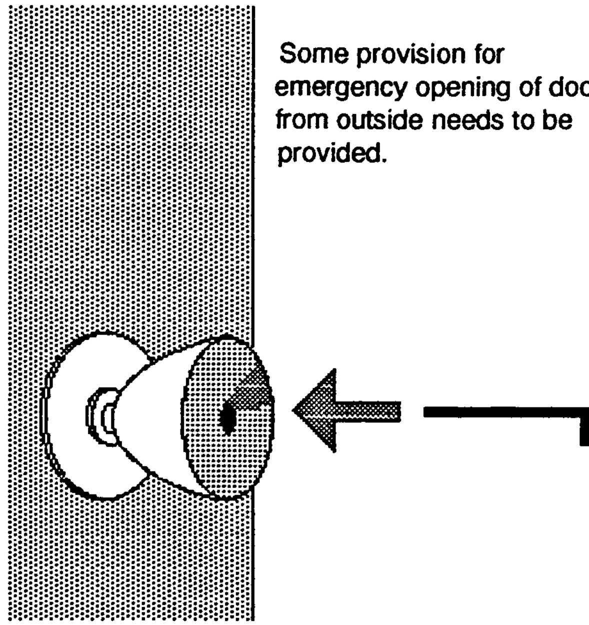
Bathroom doors should be unlockable from both sides of the door so that people can get in to rescue a child or injured person. But provisions for emergency access must be balanced against needs for privacy.

SOURCE(S)

Knox, 1983.

ILLUSTRATION

Some provision for emergency opening of doors from outside needs to be provided.



Door hinges on opposite side of control valves for easy access. | **6 0**

DESIGN COMPONENT(S)

Door

THREAT(S)

Thermal, Mechanical

PROBLEM(S)

Difficult accessibility to the control from outside of tub or shower can cause hot water burns or falls.

NOTE

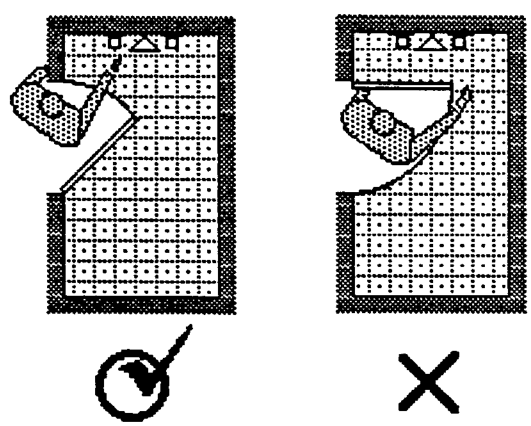
Door hinges should be placed on the side opposite control valves for easy accessibility to the controls from a safe, comfortable position.

SOURCE(S)

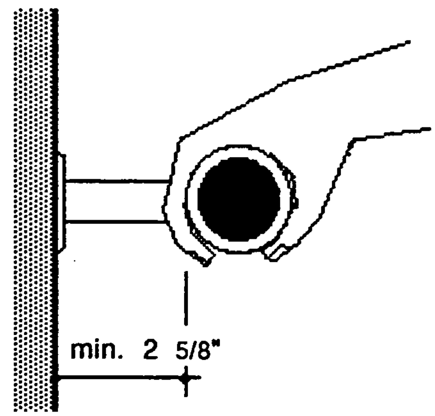
Knox, 1983; Teledyne Brown

ILLUSTRATION

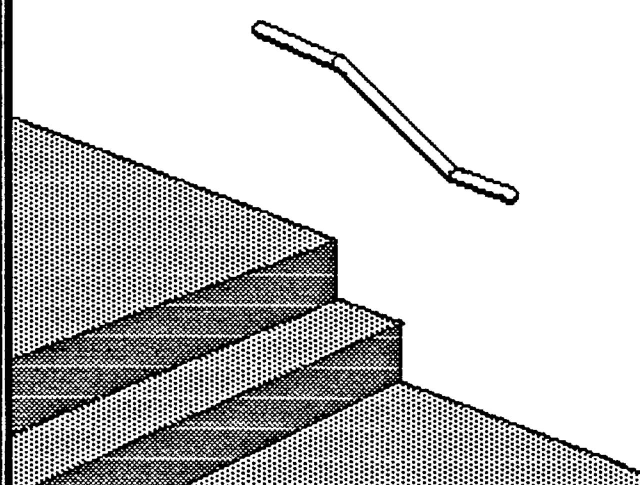
To prevent hot water burns and falls due to difficult accessibility to the controls, door hinges should be placed on the side opposite control valves.



Enough clearance between handrails and walls to allow fast grasp.	6 1
DESIGN COMPONENT(S) Grab-bar/Handrail	**ILLUSTRATION** Handrail should be set out far enough from the wall to allow fast and solid grasp.
THREAT(S) Mechanical	
PROBLEM(S) Inadequately built handrails do not permit fast and solid grasp.	
NOTE Handrails at level changes should be set out far enough from the wall to allow a fast and good solid grasp. Minimum finger clearance from any other object is 2 5/8 inch (65 mm).	
SOURCE(S) Sinnott, 1985.	



Handrails shaped to indicate level changes by touch.	6 2
DESIGN COMPONENT(S) Grab-bar/Handrail	**ILLUSTRATION** Handrail should tell the floor level change by touch. This is very helpful in the dark, and for people with visual deficiency.
THREAT(S) Mechanical	
PROBLEM(S) Misperception of level changes causes fall accidents, especially in dark environments.	
NOTE The rail end should be specially shaped so that individuals can tell by touch that they have reached the bottom level.	
SOURCE(S) Thygerson, 1977; Sinnott, 1985.	



Handrails on both sides of open steps to prevent falls. | 63

DESIGN COMPONENT(S)

Grab-bar/Handrail

THREAT(S)

Mechanical

PROBLEM(S)

Many fall accidents occur near floor level changes, such as on steps or slopes.

NOTE

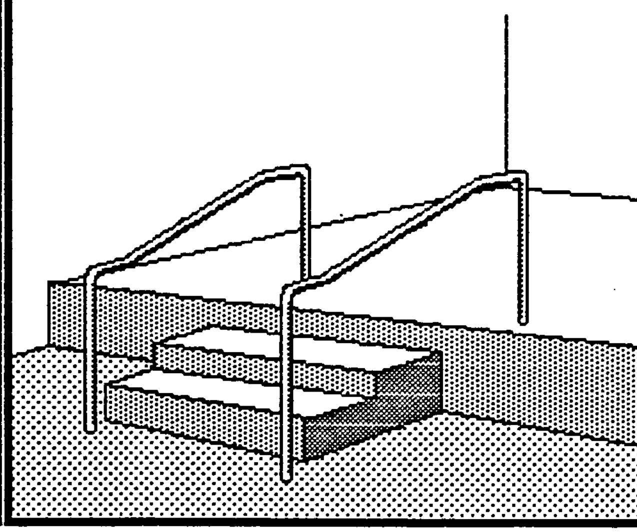
A handrail should be installed on at least one side of each level change greater than three risers. Open steps should have handrails on both sides.

SOURCE(S)

Teledyne Brown Engineering, 1972.

ILLUSTRATION

Open steps should have handrails on both sides.



Safety glazing used so as to reduce the severity of accidents. | 64

DESIGN COMPONENT(S)

Door/Window

THREAT(S)

Mechanical

PROBLEM(S)

Breaking glass on bathtub and shower enclosures can cause serious cuts.

NOTE

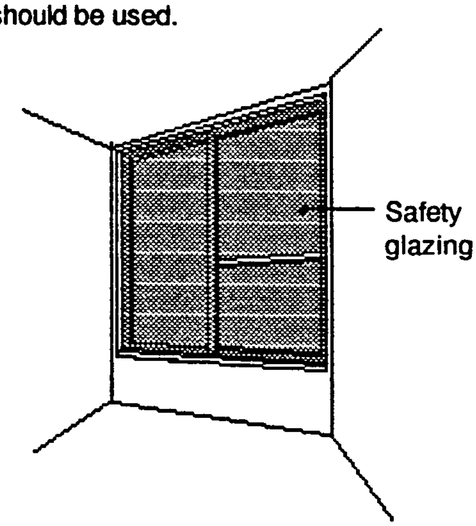
Use safety glazing that won't break or cause injury when broken. Safety glazing includes tempered, laminated, wired, organically coated, and plastic glass, etc.

SOURCE(S)

Sinnott, 1985; Rush, 1981; BOSTI,

ILLUSTRATION

To prevent glass-related accidents, or at least, reduce their severity, safety glazing should be used.



Grab bars near tubs to help entry and exit. 6 5

DESIGN COMPONENT(S)

Grab-bar/Handrail

THREAT(S)

Mechanical

PROBLEM(S)

Most of the fall accidents related to tubs/showers occur when people get in or out of the tub.

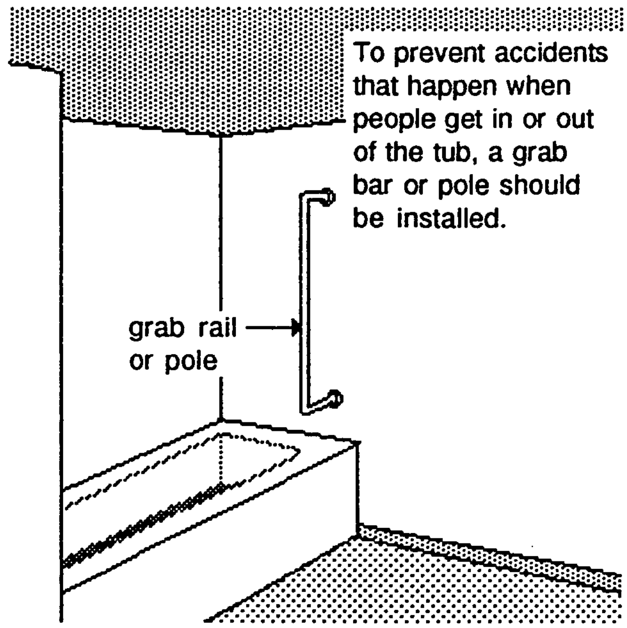
NOTE

At least a grab rail or pole should be installed to help getting in or out of the tub.

SOURCE(S)

Sinnott, 1985.

ILLUSTRATION



Strongly installed grab bars to support minimum 250 lb. 6 6

DESIGN COMPONENT(S)

Grab bar/Handrail

THREAT(S)

Mechanical

PROBLEM(S)

Accidents happen when a disabled person uses any supporting members, such as towel bars or paper holders that do not have the capability of

NOTE

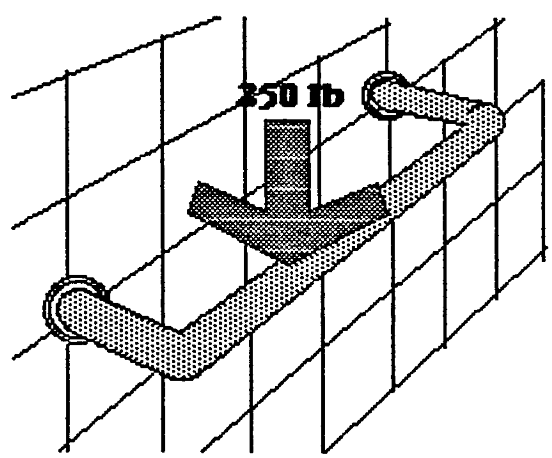
Every supporting members should be capable of supporting at least 250 lb. of stress at every point for 5 minutes without permanent deflection.

SOURCE(S)

Raschko, 1982; Harkness, 1976.

ILLUSTRATION

Supporting members must be capable of 250 lb. of stress at every point, as people are apt to use anything available for support in an emergency.



Handrails on the right side of descending steps. 67

DESIGN COMPONENT(S)

Grab-bar/Handrail

THREAT(S)

Mechanical

PROBLEM(S)

Most stair accidents occur while descending, many at floor level changes where handrails are missing or incorrectly placed.

NOTE

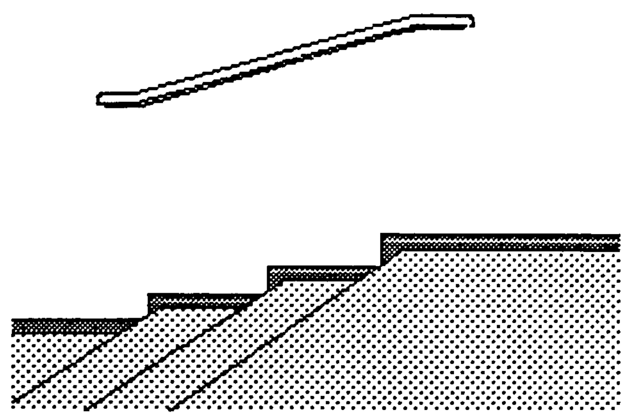
Besides being right handed, most users (right and left handed) stay to the right in all walkways and therefore will be at the right side when approaching stairs and most likely to benefit from handrails on that side.

SOURCE(S)

Teledyne Brown Engineering, 1972.

ILLUSTRATION

Because most people are right-handed, at least one handrail should be installed on descending steps on the right side.



Grab-bars recessed so as to eliminate projecting edges. 68

DESIGN COMPONENT(S)

Grab-bar/Handrail

THREAT(S)

Mechanical

PROBLEM(S)

When people slip and fall, they hit their heads or body parts against protrudent fittings.

NOTE

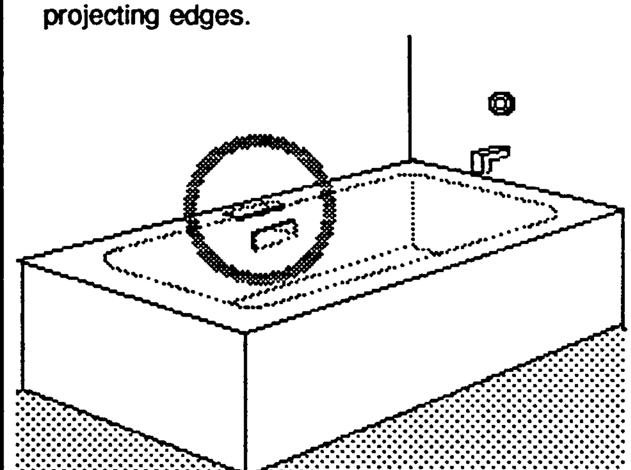
Hand-grips should be incorporated (recessed, flush, etc.) so as to minimize projecting edges.

SOURCE(S)

Conran, 1978; Knox, 1983.

ILLUSTRATION

To prevent accidents of hitting body parts against protrudent fittings, grab-bars should be installed in a way that eliminates projecting edges.



Adequate clearances between grab bars and walls. | 69

DESIGN COMPONENT(S)

Grab bar/Handrail

THREAT(S)

Mechanical

PROBLEM(S)

Too large a clearance between the grab bar and the wall can be dangerous for the handicapped. Their hands or arms can easily slip into the gap.

NOTE

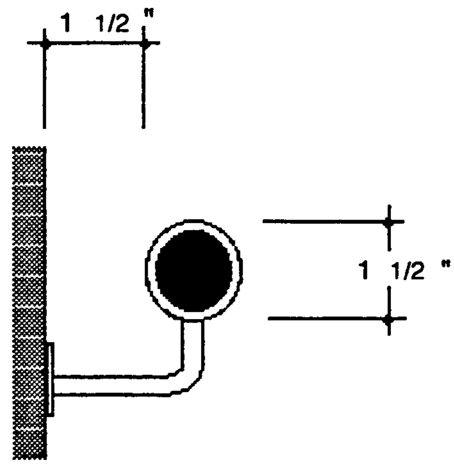
The clearance between the bar and the wall should not be greater than 1 1/2 inches.

SOURCE(S)

Harkness, 1976.

ILLUSTRATION

For the handicapped, the clearance between the grab bar and the wall should not exceed 1 1/2 inches.



Grab bars shaped to allow solid grip. | 70

DESIGN COMPONENT(S)

Grab bar/Handrail

THREAT(S)

Mechanical; Physiological

PROBLEM(S)

The use of rectangular grab bars or handrails do not allow a power grip.

NOTE

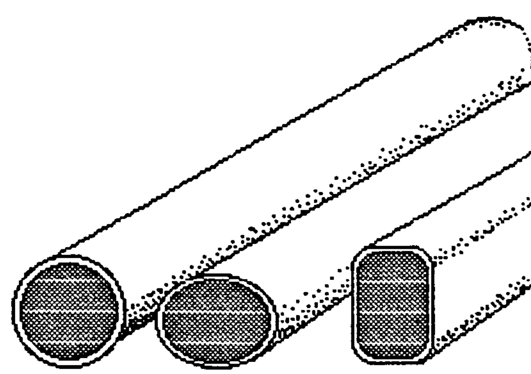
Grab bars and handrails should be circular, oval, or oblong in cross section. A handrail diameter of 1 3/4 - 2 in. (45-50 mm) is recommended, with a maximum width for a shaped rail of 2 5/8 in. (65 mm).

SOURCE(S)

Sinnott, 1985; Rush, 1981;

ILLUSTRATION

To allow a solid power grip, the cross sections of handrail should be circular, oval, or oblong rather than squared or rectangular in shape.



Illuminated edges of level changes to increase the visibility.	71

DESIGN COMPONENT(S)

Artificial; Natural Lighting

THREAT(S)

Mechanical

PROBLEM(S)

Unclear visibility of the edges of level changes is one of the major reasons of fall accidents.

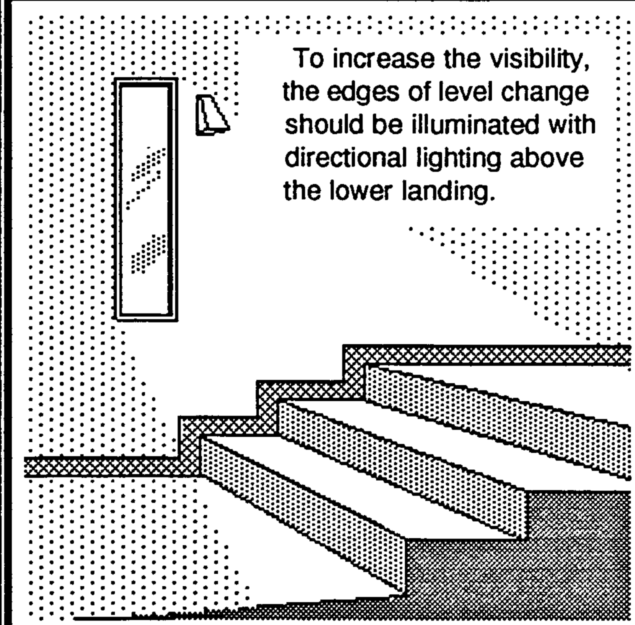
NOTE

The edges should be illuminated with directional lighting from sources located above the lower landing.

SOURCE(S)

Sinnott, 1985.

ILLUSTRATION



Confined germicidal UV lighting to avoid irritation.	72

DESIGN COMPONENT(S)

Artificial Lighting

THREAT(S)

Chemial, Electrical

PROBLEM(S)

The germicidal UV radiation is irritating to skin and eyes.

NOTE

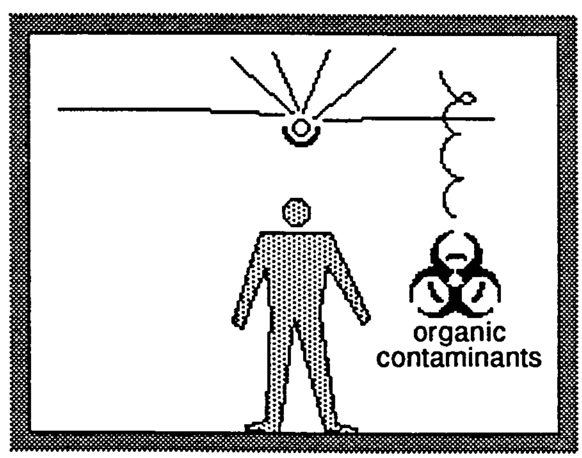
The germicidal UV lighting must be confined to the space between the top of people's head and the ceiling.

SOURCE(S)

Riley,1988.

ILLUSTRATION

Germicidal UV lighting should be confined to the space between the top of people's head and the ceiling to avoid irritation of skin or eyes.



Use focus lighting for visual privacy.	73

DESIGN COMPONENT(S)

Artificial Lighting

THREAT(S)

Emotional

PROBLEM(S)

When two or more people must use a bathroom simultaneously, they may feel uncomfortable due to a lack of visual privacy.

NOTE

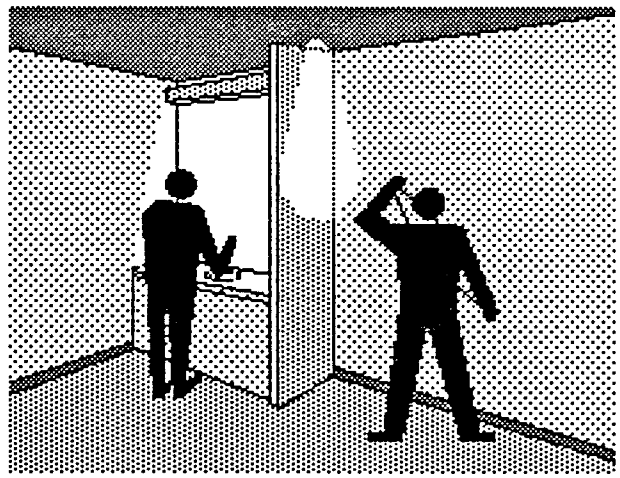
For some tasks (applying make-up, grooming, etc.), both the activity and the individual may have to be lit, but these are generally tasks where privacy is less important.

SOURCE(S)

Miller, 1985.

ILLUSTRATION

Where possible, focus lighting on activities rather than people to maintain visual privacy while providing adequate light for tasks.



Night lights to prevent bumping due to total darkness.	74

DESIGN COMPONENT(S)

Artificial Lighting

THREAT(S)

Mechanical

PROBLEM(S)

Total darkness cause bumping and fall accidents, especially of the elderly.

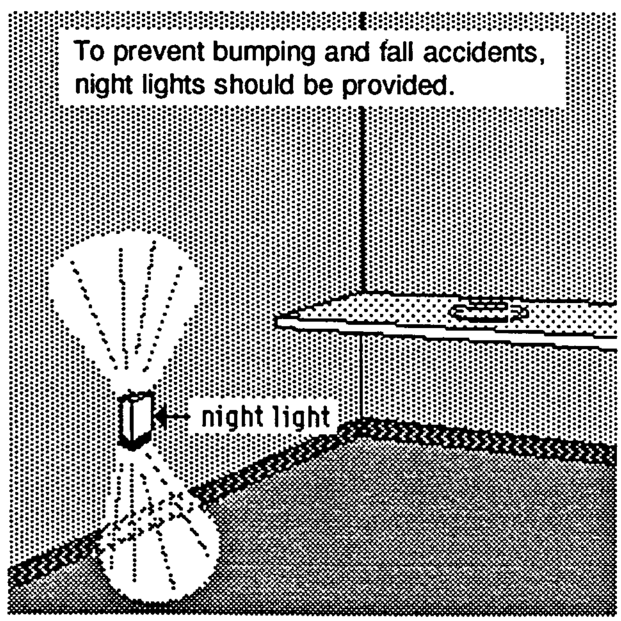
NOTE

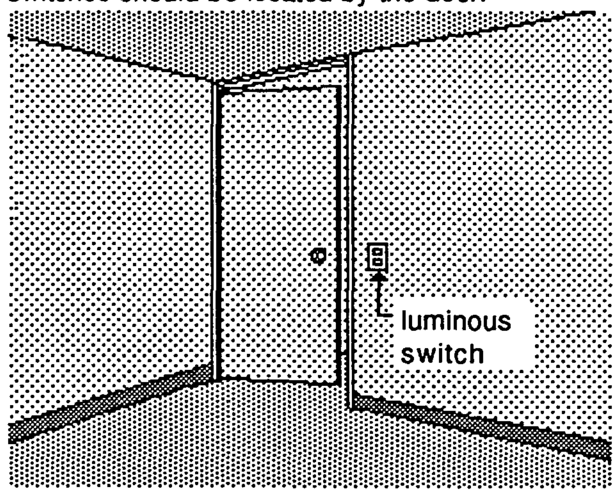
Night light provides, at least, minimum illumination that enable people to identify the major structure of the bathroom.

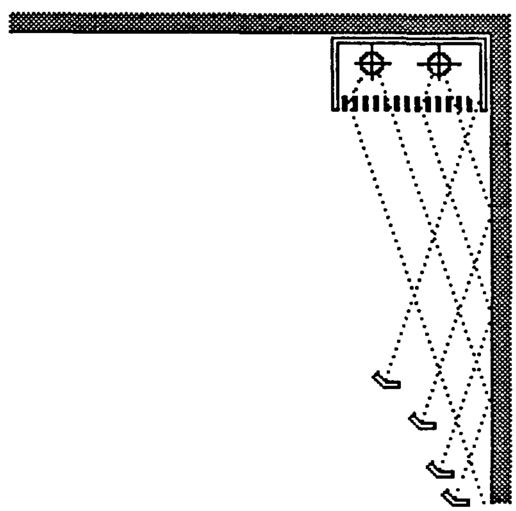
SOURCE(S)

Kira,1976; Knox, 1983.

ILLUSTRATION



Luminous light switches for easy access in the dark.	75
DESIGN COMPONENT(S)	**ILLUSTRATION**
Artificial Lighting	To prevent accidents that happen while people try to find and reach to light switches, luminous switches should be located by the door. 
THREAT(S)	
Mechanical	
PROBLEM(S)	
Many accidents happen while people try to find and reach to light switches, especially at midnight.	
NOTE	
Phosphorescent, photoluminescent, switch/Nightlight combinations and switches with "pilot" lights are examples of luminous switches.	
SOURCE(S)	
Kira, 1976.	

Shielded or diffused lighting sources to prevent glare.	76
DESIGN COMPONENT(S)	**ILLUSTRATION**
Artificial Lighting	Direct glare can be alleviated through shielding the source or using a diffused source. 
THREAT(S)	
Mechanical; Emotional	
PROBLEM(S)	
Direct glare may easily make harsh feeling, and cause momentarily blind effect, which can be the secondary cause of accidents.	
NOTE	
Direct glare can be alleviated through shielding the source, or using a diffused source.	
SOURCE(S)	
Miller,1985.	

Mirror lighting shining on to person's face for eficiency. | **77**

DESIGN COMPONENT(S)

Artificial Lighting

THREAT(S)

Mechanical, Emotional

PROBLEM(S)

Inefficient mirror lighting causes misguided smears of make-up and slips of the razor.

NOTE

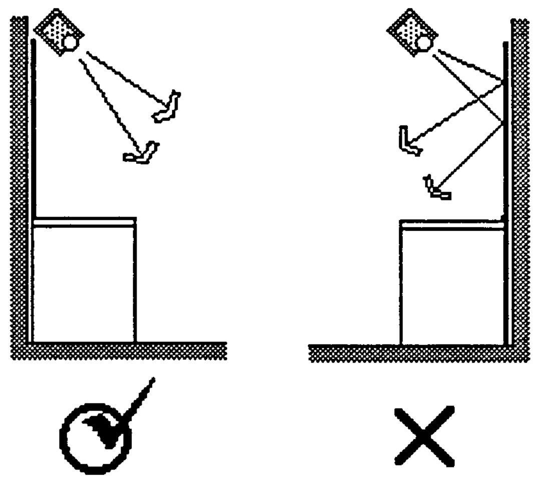
In general, users can see the directly reflected glare of the light source in the mirror.

SOURCE(S)

Raschko, 1982.

ILLUSTRATION

Efficient mirror lighting for shaving or making up should shine on to person's face, not into the mirror.



Indirect lighting to avoid glare. | **78**

DESIGN COMPONENT(S)

Artificial Lighting

THREAT(S)

Mechanical, Emotional

PROBLEM(S)

Direct glare may easily make harsh feeling, and momentarily blind users, which can be the secondary cause of accidents.

NOTE

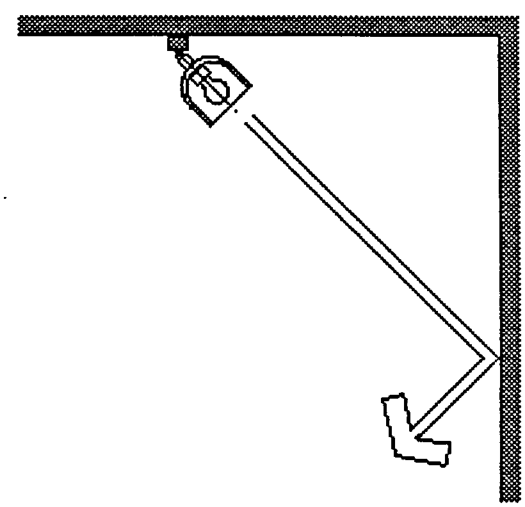
Glare can be eliminated by using indirect instead of direct lighting. Even though indirect lighting is used, highly reflective surfaces can cause secondary glare. consider using reflective light bulbs.

SOURCE(S)

Miller, 1985.

ILLUSTRATION

To avoid direct glare that can cause accidents, indirect lighting should be considered.



Sunlamps attached with timer-switches to prevent burns. 79

DESIGN COMPONENT(S)

Artificial Lighting

THREAT(S)

Thermal

PROBLEM(S)

Exceeding the recommended time limits of exposure under sunlamps can cause burn accidents.

NOTE

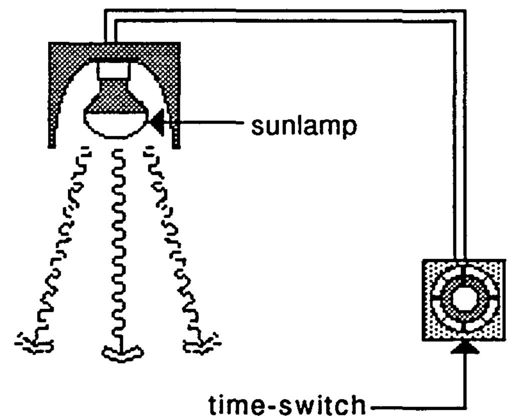
Time-switches should be calibrated so the "maximum" setting is still within safe time limits.

SOURCE(S)

Knox, 1983.

ILLUSTRATION

To prevent burns by sunlamps, they should be attached with time-switches.



At wet areas, use GFCIs to prevent electric shock. 80

DESIGN COMPONENT(S)

Electricity

THREAT(S)

Electrical

PROBLEM(S)

Electric shock

NOTE

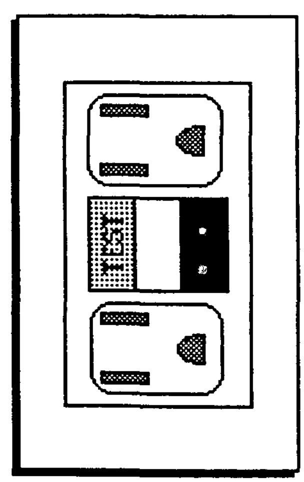
Ground-Fault Circuit Interrupter (GFCI) can prevent electric shock by snapping off the power within 25 milliseconds.

SOURCE(S)

Self,1981; BOSTI,1984.

ILLUSTRATION

GFCI can prevent electric shock by cutting off electric power within 25 milliseconds.



Three-prong type electric outlets to prevent shock. | **8 1**

DESIGN COMPONENT(S)

Electricity

THREAT(S)

Electrical

PROBLEM(S)

Not-grounded electric appliances have great possibility of electric shock.

NOTE

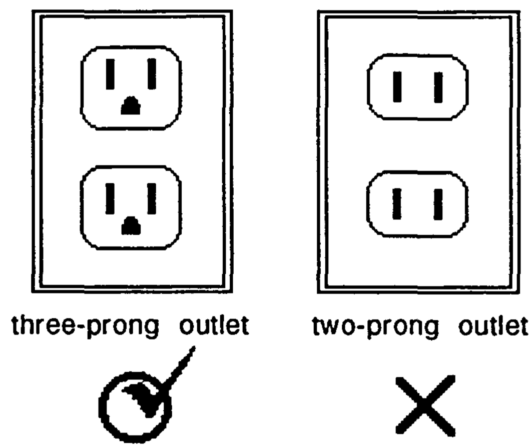
To make all major appliances grounded, electric outlets should be grounded, and equipped with three-prong types.

SOURCE(S)

BOSTI,1984.

ILLUSTRATION

To prevent electric shock, all electric outlets should be grounded three-prong types.



Permanently installed space heaters to prevent electric shock. | **8 2**

DESIGN COMPONENT(S)

Electricity

THREAT(S)

Electrical

PROBLEM(S)

Handling movable space heaters in a wet place like bathroom is extremely in danger of electric shock.

NOTE

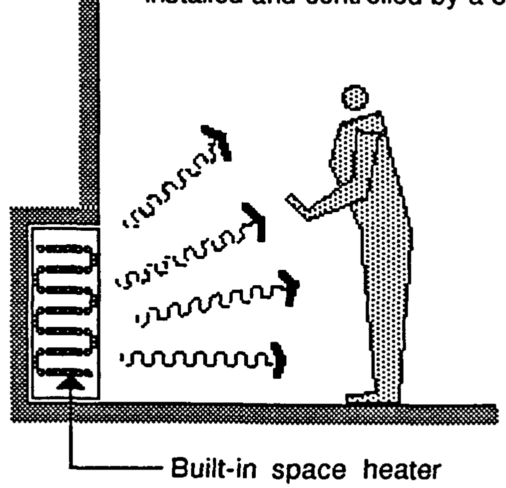
Heater should be permanently installed and controlled by a switch rather than a plug.

SOURCE(S)

Mansfield, 1989.

ILLUSTRATION

To prevent electric shock, space heater should be permanently installed and controlled by a switch.



Electrical outlets out of reach from tubs/showers. 83

DESIGN COMPONENT(S)
Electricity

THREAT(S)
Electrical

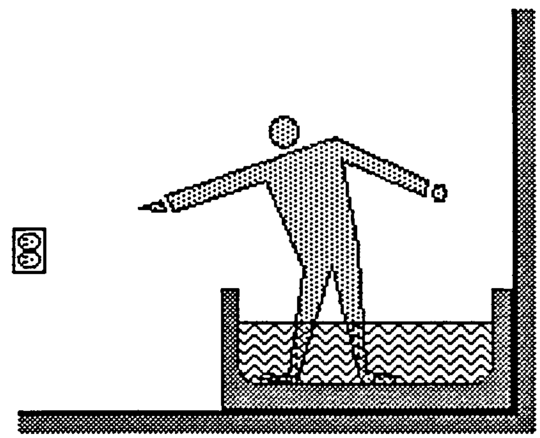
PROBLEM(S)
Electric shock

NOTE
Receptacles should be placed out of arm's reach from faucets, especially from bathtub/shower.

SOURCE(S)
Mazzurco, 1986.

ILLUSTRATION

Electrical outlet should be out of the reach from tub/shower to prevent electric shock.



Adequate colors and patterns to show areas needing cleaning. 84

DESIGN COMPONENT(S)
Color/Pattern

THREAT(S)
Organic

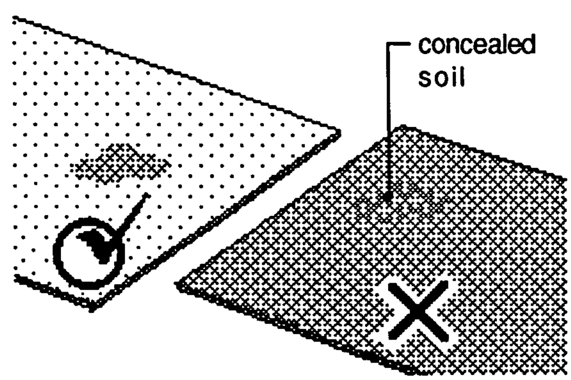
PROBLEM(S)
It is difficult to find and clean out dirt on the floor materials which colors and patterns hide dirt.

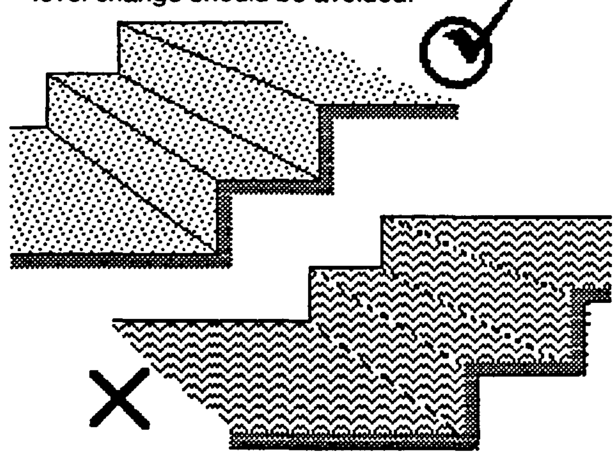
NOTE
From the standpoint of sanitation, floor carpet or other materials should have adequate colors and patterns which show up dirt.

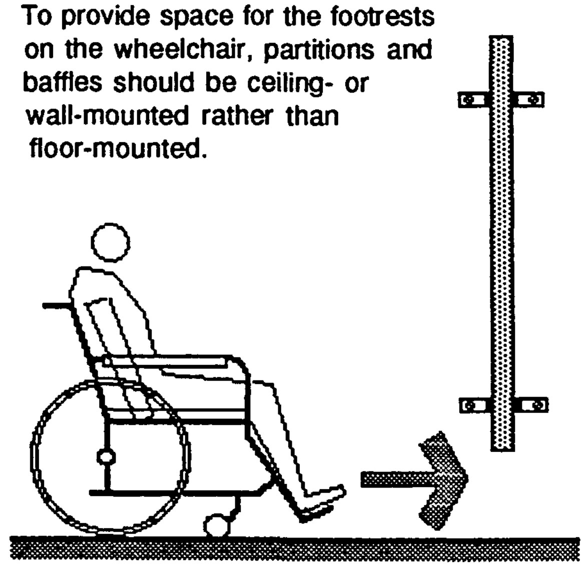
SOURCE(S)
Kira,1976.

ILLUSTRATION

To find and clean out dirt on the floor easily, floor materials should have colors and patterns that show up dirt.



Adequate colors/patterns to prevent visual disorientation.	85
DESIGN COMPONENT(S)	**ILLUSTRATION**
Color/ Pattern	To prevent visual disorientation or confusion that causes fall accidents, horizontal patterns running parrallel or perpendicular to floor level change should be avoided. 
THREAT(S)	
Mechanical	
PROBLEM(S)	
Visual disorientation or confusion created by endless geometric or randomized pattern at floor level change causes fall accidents.	
NOTE	
Horizontal patterns running parallel or perpendicular to floor level change should be avoided. Provide uniformly textured, plain-colored surface.	
SOURCE(S)	
Davidson, 1989; Archea, 1979.	

Ceiling- or wall-mounted partitions for wheelchair users.	86
DESIGN COMPONENT(S)	**ILLUSTRATION**
Wall/Partition	To provide space for the footrests on the wheelchair, partitions and baffles should be ceiling- or wall-mounted rather than floor-mounted. 
THREAT(S)	
Mechanical	
PROBLEM(S)	
Floor mounted baffles and partitions obstruct the footrests on the wheelchair.	
NOTE	
Ceiling or wall-mounted baffles and partitions provide the space for the footrests on the wheelchair.	
SOURCE(S)	
Harkness, 1976.	

Walls/partitions arranged so as to permit smooth air movement. | 8 7

DESIGN COMPONENT(S)

Wall/ Partition

THREAT(S)

Organic

PROBLEM(S)

Directional changes in air movement due to wall or partition arrangement may result in deposition of particles.

NOTE

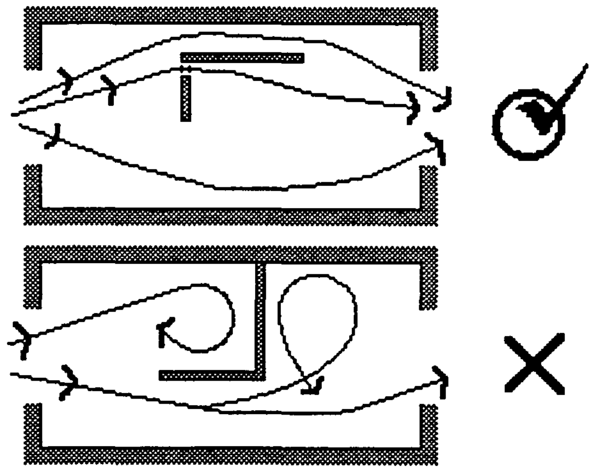
The fewer directional changes of air movement, the less deposition of particles.

SOURCE(S)

Rodahl, 1986; Melaragno,1982.

ILLUSTRATION

To prevent deposition of particles due to directional changes in air movement, wall arrangement should be carefully determined.



Wall surfaces smooth-textured so as not to retain particles. | 8 8

DESIGN COMPONENT(S)

Wall/ Partition

THREAT(S)

Organic

PROBLEM(S)

Rough-textured surfaces tend to retain particles, and are difficult to clean.

NOTE

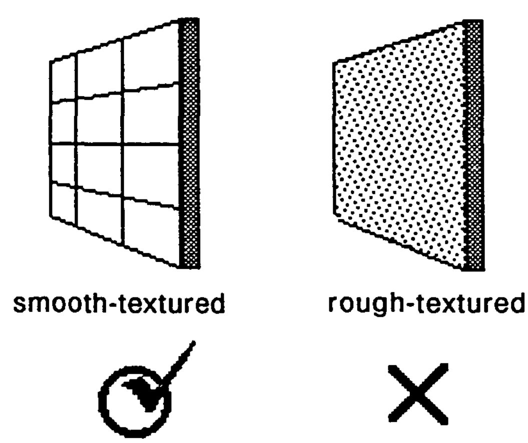
Smooth-textured materials such as tiles and laminated panels are more adequate for bathroom walls than rough-textured surfaces.

SOURCE(S)

Sinnott, 1985.

ILLUSTRATION

As rough-textured surfaces are effective in retaining particles, smooth-textured walls are recommended.



Furnishings attached to walls to reduce sound transmission.	89

DESIGN COMPONENT(S)

Wall/Partition

THREAT(S)

Emotional

PROBLEM(S)

People are very sensitive about the noise they make while they use bathroom fixtures, especially water closet.

NOTE

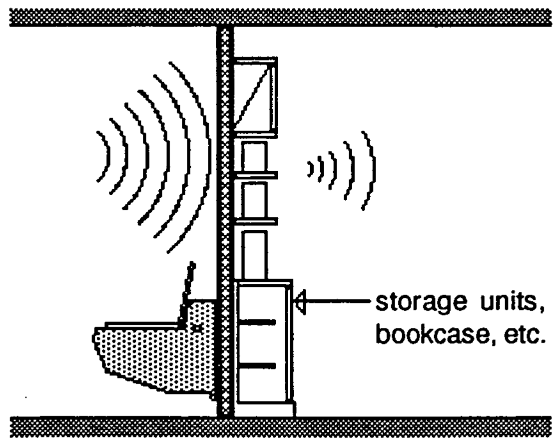
Placing storage units or bookcases along walls that transmit sound can be helpful; air space between the unit and the wall is recommended.

SOURCE(S)

Miller,1985.

ILLUSTRATION

To reduce sound transmission from bathrooms, place storage units, bookcase, or other furniture along walls as baffles, or sound absorbing methods.



Insulated walls/partitions to reduce sound transmission.	90

DESIGN COMPONENT(S)

Wall/Partition

THREAT(S)

Emotional

PROBLEM(S)

People are very sensitive about the noise they make while they use bathroom fixtures, especially water closet.

NOTE

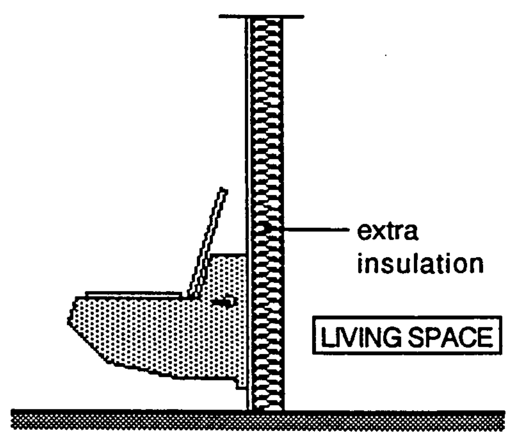
Placing extra insulation between bathrooms and other living quarters reduces sound transmission.

SOURCE(S)

Miller, 1985.

ILLUSTRATION

To reduce sound transmission, extra insulation should be installed between bathrooms and other living spaces.



Partitions combined with orientation differences for privacy.	91

DESIGN COMPONENT(S)

Wall/Partition

THREAT(S)

Emotional

PROBLEM(S)

When two or more people must use a bathroom simultaneously, they may feel uncomfortable due to a lack of visual privacy.

NOTE

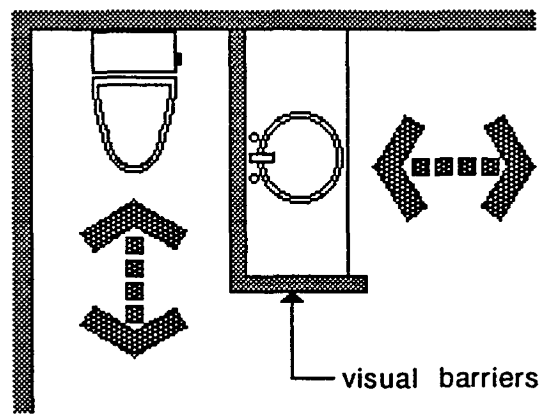
Partial visual barriers combined with slight orientation differences, for instance, between 90° and 180°, can reduce the visual exposure.

SOURCE(S)

Miller, 1985.

ILLUSTRATION

Partial visual barriers combined with orientation differences can provide visual privacy when a bathroom is used at the same time by more than one person.



Walls with blocking inside for future grab bars.	92

DESIGN COMPONENT(S)

Wall/Partition

THREAT(S)

Mechanical; Physiological

PROBLEM(S)

It is difficult to attach grab bars on the bathroom walls because there is no adequate blocking built into walls.

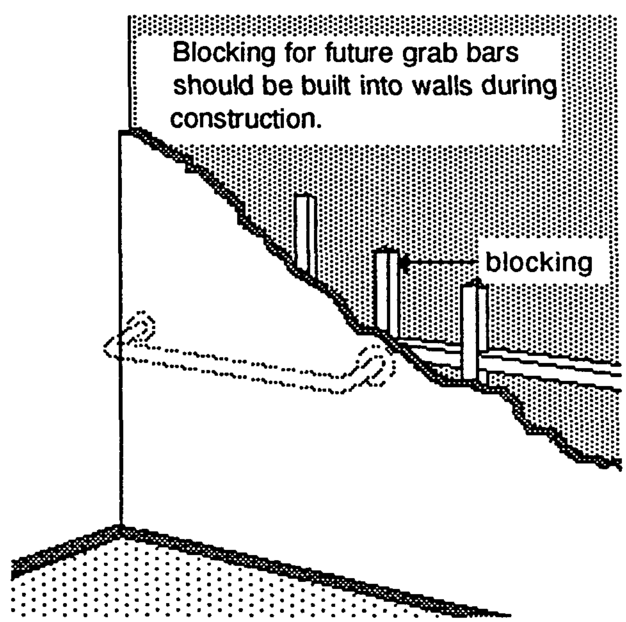
NOTE

Blocking for future grab bar installation should be built into the bathroom walls during an apartment or housing development.

SOURCE(S)

Harkness, 1976.

ILLUSTRATION



Walls with vapor barriers inside to prevent moisture intrusion.	9 3

DESIGN COMPONENT(S)

Wall/Partition

THREAT(S)

Oranic

PROBLEM(S)

Water vapor diffuses into building cavities, where is almost impossible to dry up, and becomes to gather mold.

NOTE

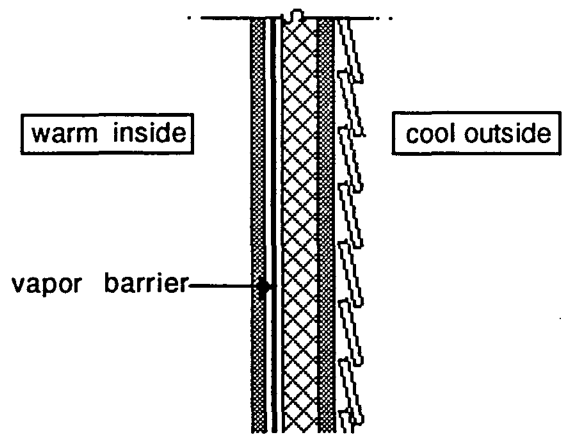
Diffusion of water vapor into building can be controlled by placing a vapor barrier on the warm side of walls and ceiling. Typical vapor barrier materials are: polyethylene plastic, aluminum foil, and low-permeability

SOURCE(S)

Godish,1989.

ILLUSTRATION

To prevent vapor diffusion into building cavities, place a vapor barrier on the warm side of walls and ceiling.



Smoothly finished joints on walls to prevent soil accumulation.	9 4

DESIGN COMPONENT(S)

Wall/Partition

THREAT(S)

Organic

PROBLEM(S)

Dust and soil accumulate on stepped walls/partitions, and increase organic growth.

NOTE

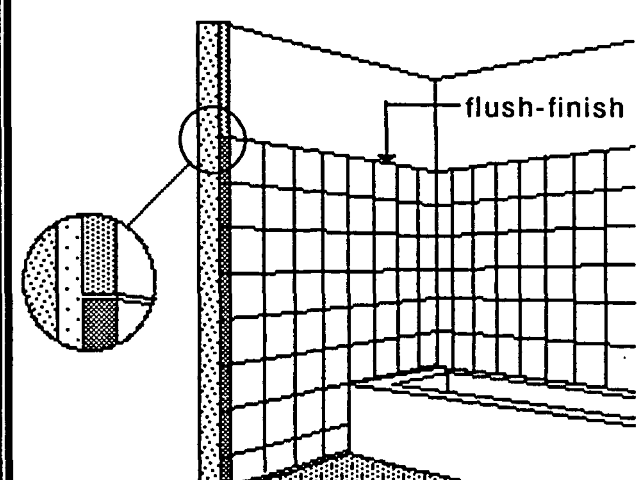
Smooth wainscots of glazed ceramic tiles or plastic laminate are preferable in heavily used facilities.

SOURCE(S)

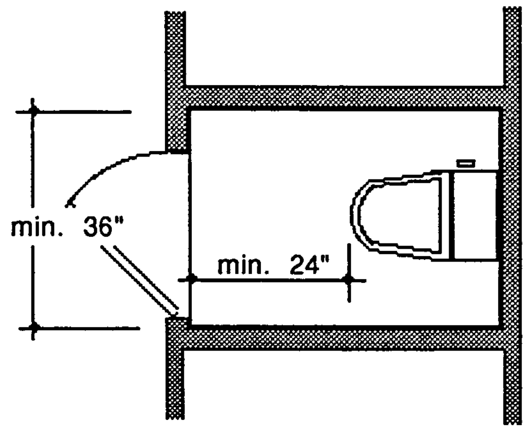
Allen,1980.

ILLUSTRATION

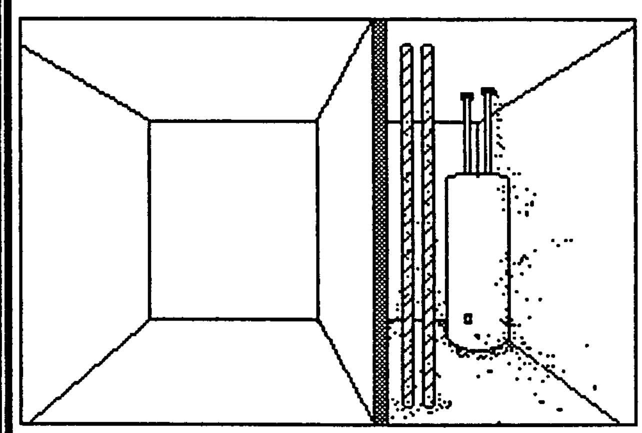
The joint of different materials on walls should be smoothly finished to prevent soil accumulation.



Spacious toilet compartments to prevent bumping.	95
DESIGN COMPONENT(S)	**ILLUSTRATION**
Wall/Partition; Toilet/Bidet	To prevent bumping into the walls or other fixture, enough space should be provided.
THREAT(S)	
Mechanical	
PROBLEM(S)	
People bump into other fixtures or walls if enough free space is not allowed.	
NOTE	
A space 3 feet wide is needed if toilet is located between two walls; 28" wide, if toilet is between bathtub and lavatory or vanity; 32" wide for toilet between a wall and another fixture.	
SOURCE(S)	
Panero, 1979.	



Remaining asbestos (when required) confined to eliminate hazard.	96
DESIGN COMPONENT(S)	**ILLUSTRATION**
Other	To eliminate health hazards of asbestos, all friable asbestos application should be enclosed, encapsulated, or removed.
THREAT(S)	
Chemical	
PROBLEM(S)	
Friable asbestos can causes lung cancer, mesothelioma, asbestosis, and many other diseases.	
NOTE	
Do not use asbestos products. Already constructed asbestos application should be enclosed, encapsulated, or removed.	
SOURCE(S)	
Godish, 1989; Turiel,1985.	



Cabinetry with safety latches to prevent access by children. | 9 7

DESIGN COMPONENT(S)

Other

THREAT(S)

Chemical

PROBLEM(S)

Childen, especially young children try to reach and swallow anything they can get.

NOTE

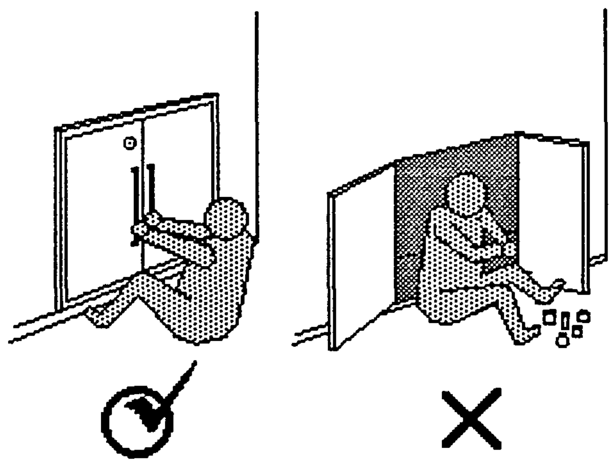
Safety latches should be installed on cabinetry and storage areas where drugs, cleaning liquid, and other harmful materials are stored.

SOURCE(S)

Mazzurco,1986; Sinnott, 1985;

ILLUSTRATION

cabinetry and storage areas should be installed with safety latches to prevent young children's drug or chemical accidents.



Masking sounds to provide acoustical privacy. | 9 8

DESIGN COMPONENT(S)

Other

THREAT(S)

Emotional

PROBLEM(S)

People are very sensitive about the noise they make while they use bathroom fixtures, especially water closet.

NOTE

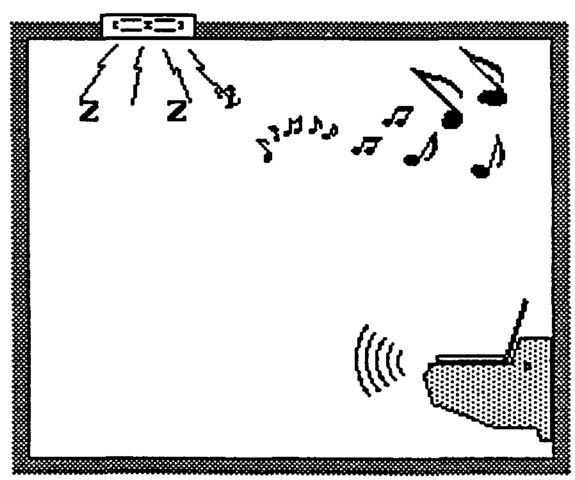
Acceptable masking sounds such as vent fan noise, white noise, and music can provide acoustic privacy.

SOURCE(S)

Miller,1985; Kira,1976.

ILLUSTRATION

To provide acoustic privacy, use masking sound such as vent fan noise, white noise, music, etc.



Clothes hooks placed higher than head level height. | **99**

DESIGN COMPONENT(S)

Other

THREAT(S)

Mechanical

PROBLEM(S)

Clothes hooks attached to doors at or below head level cause serious injuries.

NOTE

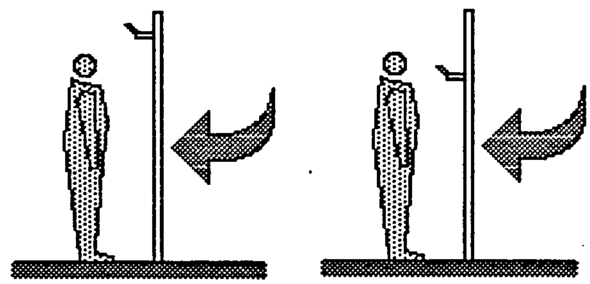
If possible, place clothes hooks on the wall rather than movable doors. The hooks should have rounded edges.

SOURCE(S)

Teledyne Brown Engineering, 1972.

ILLUSTRATION

Clothes hooks on doors or walls should be placed above head level height.



clothes hooks above head level height

clothes hooks below head level height

Recessed/flush fittings to eliminate protrudent sharp edges. | **100**

DESIGN COMPONENT(S)

Other

THREAT(S)

Mechanical

PROBLEM(S)

When people slip and fall, protrudent shelves and storage cabinet edges can cause head and body injuries.

NOTE

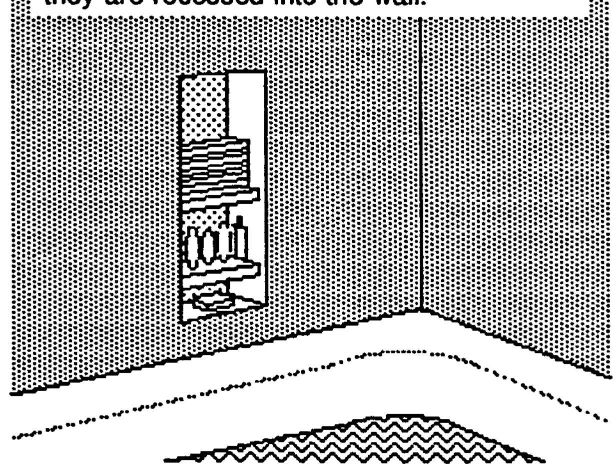
This applies to a wide range of features, including shelves, cabinetry, soap dishes and other fittings which should be installed so that they are recessed into the wall and flush.

SOURCE(S)

Knox, 1983; Teledyne Brown

ILLUSTRATION

To prevent accidents of hitting body parts against protrudent fittings, soap dishes and other accessories should be installed so that they are recessed into the wall.



Rounded corners to prevent grazes and stagnant water.	101

DESIGN COMPONENT(S)

Other

THREAT(S)

Mechanical, Organic

PROBLEM(S)

Sharp edges and corners cause grazed shins and unpleasant build-ups of stagnant water.

NOTE

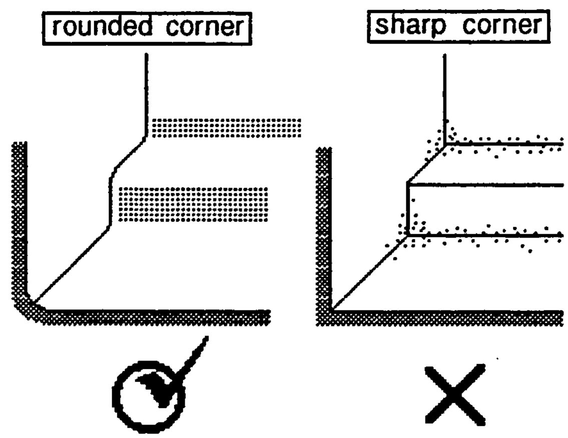
Rounded corners and streamlined surfaces make cleaning easier and lessen the risk of grazed shins.

SOURCE(S)

Conran, 1978.

ILLUSTRATION

To prevent grazed shins and unpleasant build-up of stagnant water, make rounded corners and streamlined surfaces.



Easily operable call buttons for emergency cases.	102

DESIGN COMPONENT(S)

Other

THREAT(S)

Physiological

PROBLEM(S)

In case of emergency, people need some device torequest help outside of the bathroom.

NOTE

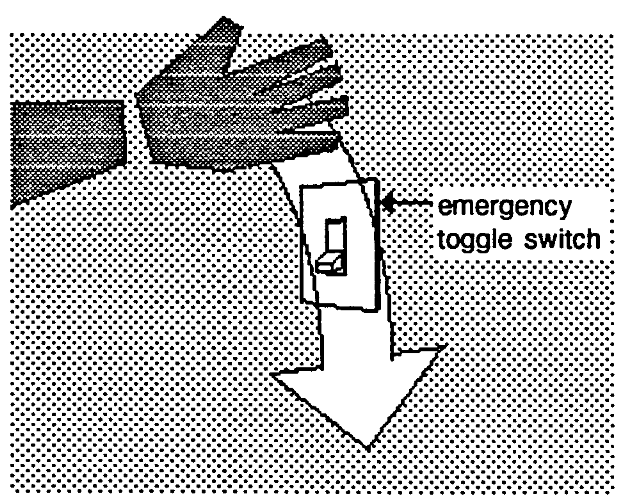
Emergency call button should be equipped. The toggle switch type is preferable because it is easily operated by a simple sweeping action.

SOURCE(S)

Raschko, 1982.

ILLUSTRATION

As an emergency call button, the toggle switch type is preferable.



CHAPTER V. DISCUSSION

In the process of this study, several strengths and weaknesses in surveying information and developing a morphological summary were exposed. This self-evaluation can be useful for future extended studies of this topic and for other research employing similar research methods.

Strengths

Even though safety and health issues have aroused designer's interest for more than a decade, most related information is quite general and tends to be scattered throughout other literature. Initially, one of the strengths of this study was its provision of a more specialized look at the subject, focusing on a narrow range of concerns in a limited environment--the bathroom. As a result, specific and detailed research was possible.

Studies by BOSTI and Teledyne Brown Engineering Co., for example, have focused almost exclusively on threats to safety, virtually ignoring threats to health--especially emotional threats. By contrast, this author tried to give equal emphasis to health and safety threats. Threats to safety are in the majority and "mechanical" is still the most frequently used threat category in illustrated data units (see Figure 4). However, shear number of references can be misleading. Mechanical threats are, in fact, the most frequent source of actual injuries and perhaps deserve greater attention in such a database. In this case, data units classified as "mechanical" are also classified as some additional threat(s) so that the actual percentage of units devoted exclusively to mechanical is far less than a numerical break-down would indicate.

Another strength of this study is its successful combination of the morphological approach with the computer. As the primary functions of morphological activity are dissecting forms, defining subparts, and combining subparts, a bathroom environment was dissected and defined into the data units as subparts. Those data units are supposed to be easily combined together. Figure 5 shows an example of several data units combined into a single representative solution.

Several specific benefits of using the computer were observed. First, data units can easily be added or deleted, and as a result, information can be easily up-dated. Second, by obtaining a floppydisk containing the listed information, a reader of this study gains convenient access to its result of this study allowing use of his or her own computer(s).

Overall, the database proved to be a highly effective means of summarizing complex safety and health information. Specifically, its strengths are as follows:

1) It allows key word access to all categories except for text in illustrations. Any word, or even a part of a word, can be searched by using the "find" command in the FileMaker program.
2) It allows data to be priority sorted. For example, data units in this study were sorted first by the ascending order of the design components and then by threats. In this way, users can

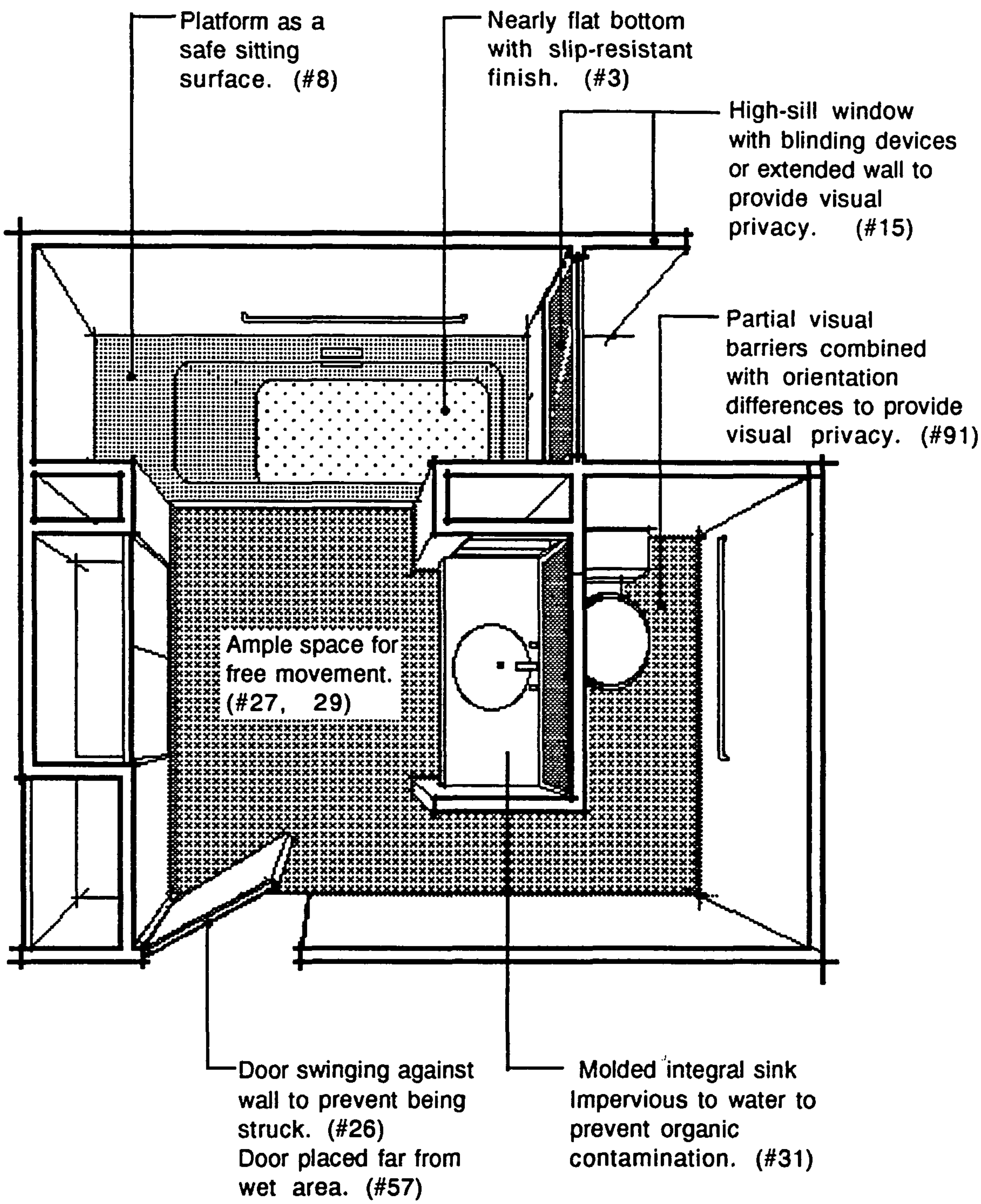


Figure 5 Example of Combination of randomly selected Data Units

conveniently change the order in which collected information is sorted and retrieved.

3) Once a different layout has been created, FileMaker allows data to be entered into it without further manipulation. After creating several different layouts, users can easily switch from one to another (see Figure 6).
4) With the computer set in a Multi-Finder mode, illustrations can be quickly passed into word-processing documents to enrich programming documents.
5) With minor revisions, the layout form could be adapted to a wide range of design elements--not just safety/health database.

In practical application of this study's data units are expected to be used differently according to the users' characters or professions. For example, practicing designers such as interior designers or architects can use the data units as a checklist of safety and health aspects of their projects both at the preliminary stage and during design developing stage. For general home owners, the units can be used to draw attention to safety and health problems in the bathroom, and to provide possible solutions. Environmental design students can use this units to understand the significance of safety and health problems, and furthermore, to understand how literature information can be developed and converted into actual design applications.

Carpeting with waterproof base to prevent organic growth. 23

DESIGN COMPONENT(S)

Floor

THREAT(S)

Organic

PROBLEM(S)

In case of overflow, water permeates into the floor structure which is hard to dry out.

NOTE

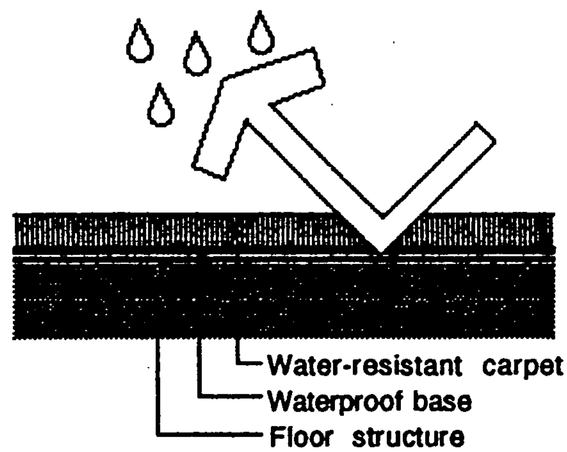
Carpeted floor should have a waterproof base to keep the dried condition of floor structure.

SOURCE(S)

Conran,1978.

ILLUSTRATION

Waterproof base should be installed under the carpet to eliminate wet subfloor condition good for the growth of organic contaminants.



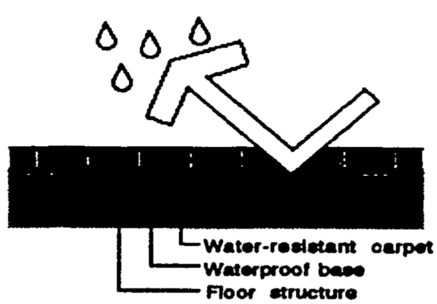
DESIGN COMPONENT(S)

Floor

HAZARD(S)

Organic

ILLUSTRATION



SOURCE(S)

Conran,1978.

PROBLEM(S)

In case of overflow, water permeates into the floor structure which is hard to dry out.

NOTE

Carpeted floor should have a waterproof base to keep the dried condition of floor structure.

EXAMPLES OF USE

John guest bathroom, El Cerrito, CA.

Figure 6. Examples of data units in different layouts

Weaknesses

During the course of the project certain limitation were also identified. For example, a main objective of this study was to provide information and data units to any designer wanting to use them with a computer. Unfortunately, the large volume of illustrated data developed requires a larger memory than many users will have available. It is also approaching a size that would prohibit storage on a single floppydisk, and, thus, is not as portable as had been expected..

As illustrations need large memory to be generated, upgrading of computer hardware is necessary to reduce the time required for using the same research methods. Moreover, for a beginner, it will take a considerable time to become familiar with all the concepts and techniques of the softwares used.

Because of the limited availability of computer software, the SuperPaint program was used for drawing illustrations. But its graphical quality, especially the slanting lines, was not fully satisfactory. Line quality could have been improved if AutoCad or similar computer-aided design software were used. An optical scanner might also have been used to make more detailed and intricate illustrations.

The illustrated data units are accompanied with condensed text information. The compactly designed layout of this study allowed the entire unit to be viewed on the small screen of a Macintosh at the same time. However, this decision also limited the amount of text information. In case the text information is too large, the whole text cannot be shown on prints (see problem section in Data Unit # 52), even though the whole text can be displayed on the computer screen when users click the cursor on those specific text fields. If extra text information were necessary, a newly revised layout would be required.

Additional Research

The illustrated data units of this study are just presenting an example that can be continually added to and developed to create a useful database. Other students could do more research on the morphological summary to improve the present capabilities. Additional environmental considerations can be included to broaden the scope of the findings of this research and to maximize their usefulness. Such a database can be expanded into a huge information database covering various and broader topics in the future.

To make a desirable reference book about safety and health problems in the bathroom, information related to public bathrooms should be added. So far, compared with other threats in the bathroom, emotional threats relating to psychological health have not been sufficiently stressed. Finally, psychological comfort in the bathroom can be further explored.

CHAPTER VI. SUMMARY AND CONCLUSION

SUMMARY

The intention of this study is to provide environmental designers both with information focused on a wide range of safety and health problems in the bathroom and with the potential solutions to such problems.

For more than a decade, safety and health issues have been the concern of environmental designers. Their concern arises from the fact that accidents and illness are often the results of normal behavior in unsafe environments, and that the causes can be eliminated through a carefully checked design process. Secondarily, designers have also come to the realization that designing safe and healthful environments is the designers' legal responsibility.

As we have a tendency to spend increasingly more time in the bathroom, it is only sensible that we become more concerned about its inherent safety and health problems. Looked at from a statistical standpoint, bathrooms are the most dangerous spaces in and around the homes. Moreover, a number of factors make the bathroom one of the least healthy places in a home. Thus, bathrooms should be targeted for particular health and safety attention by environmental designers.

Threats to safety and health can be categorized as mechanical, thermal, electrical, chemical, organic, physiological, or emotional. Under those categories, each design component can be analyzed.

Frequently, environmental designers do not have firsthand knowledge of safety and health problems in the bathroom. Therefore, an effort has been made to provide that information in easily understandable and quickly retrievable forms, that is in morphological arrangements generated by the use of a computer.

CONCLUSION

This thesis has as its goal the analysis, organization, and presentation of information on safety/health in the bathroom and of the ways in which to reduce the frequency and/or severity of accidents. Even though achieving perfect safety and health is beyond designers' abilities, they can reduce the number of injuries through carefully considered designs. If designers would take more time to study related documented research before or during the design process, the situation would improve.

Generally, accidents are not the result of a single cause. Thus, a broad knowledge of the physical and psychological limits of human tolerance and ability enables environmental designers to design safer environments. Furthermore, more studies on psycho-sociological factors of accident-proneness will be necessary to provide safer environments.

Identifying problems and suggesting possible solutions have been the core of this study. But, as BOSTI(1978) suggested, the designer's imagination should not be restricted or inhibited. Providing more diverse possible solutions can help. Thus, more in-depth research is strongly recommended.

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